PINUS STROBUS L.

A Literature Review and Discussion
Of Its Fungous Diseases in North America

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A Literature Review and Discussion Of Its Fungous Diseases in North America

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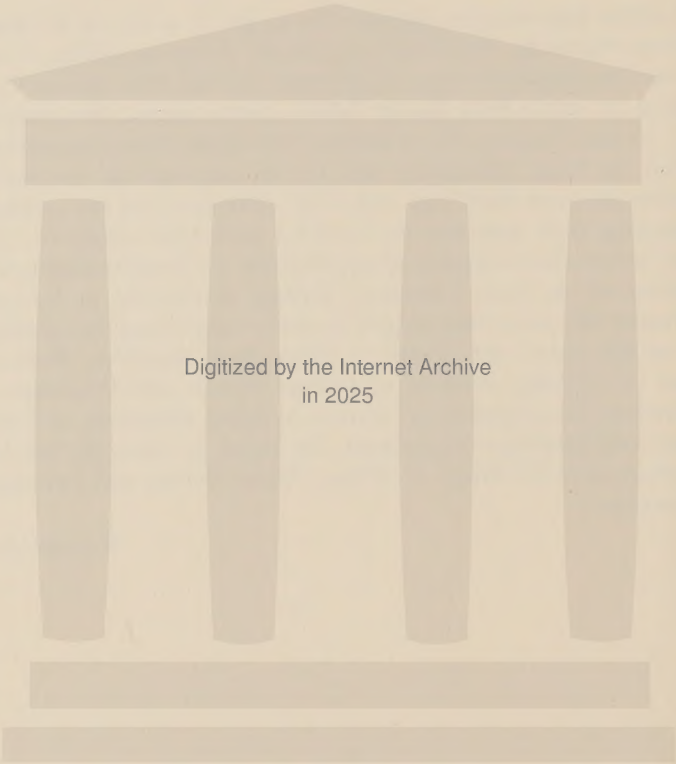
RAY R. HIRT



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INTRODUCTION

Eastern white pine, *Pinus strobus* L., is one of the largest forest trees within its natural range. Commercially, it is the most important coniferous evergreen of the northeastern forests.

White pine[1] has an abundance of desirable qualities. To many people, the beauty of a maturing white pine forest is unsurpassed. Consequently such stands constitute important recreational areas when set aside for that purpose. White pine produces seeds with relative frequency, grows rapidly, is adaptable to various sites and soils, tolerates shade and quickly responds to release. It is capable of producing clear straight-grained wood when grown in favorable environments and properly managed. Today even knotty trunks produce lumber that can be disposed of profitably. Pine wood is relatively durable, strong, dries without difficulty, is attractive in natural finish, and takes paint readily.

Because of its rapid growth and desirable wood, in the past it was used more extensively for replanting in New England and New York than any other species. At present it no longer holds first place. By natural seeding, it has taken over large areas of abandoned farm land.

In natural stands white pine has been relatively free of severe damage by native fungous pests prior to overmaturity. However, artificial methods used in reforestation practices, and the frequent poor choices of soil, site, and spacing have created situations that favor fungous attacks on poletimber, seedling and sapling trees. Foreign plant pests accidently brought into America are potential threats to native plants. The introduced foreign fungous pathogen, *Cronartium ribicola* Fischer, found eastern white pine of all ages a very susceptible host, causing the disease known as white pine blister rust. This is the most serious fungous disease of white pine within its natural range. The presence of the blister rust fungus and particularly the insect pest *Pissodes strobi* Peck, has discouraged many potential growers of eastern white pine. In spite of these destructive pests, eastern white pine will continue to be an important component of natural and

[1] Throughout this paper, "white pine" will have reference to eastern white pine, *Pinus strobus* L., unless indicated otherwise.

artificially produced stands in areas suitable for it. As better materials and methods to control the pests of white pine are developed, the tree should gain in favor. And when we substitute for the promiscuous planting of white pine a thoughtful, purposeful program of planting that will have a reasonable chance of fulfillment, the species should regain its proper place in reforestation projects.

Research on the fungous diseases of forest trees in America for many years has included studies of eastern white pine. The published results of these studies are scattered through various American publications but, so far as the writer is aware, they have never been brought together into a single reference source. Because of the importance of eastern white pine, it was deemed worthwhile to assemble the more important American references to the fungous diseases of *Pinus strobus* in North America, provide an extremely brief abstract or summary of the reference to white pine disease in each paper, and include certain personal comments on some of the more common fungous diseases. The writer has exercised the privilege of omitting reference to certain articles that seemed to contribute very little to our present knowledge of white pine diseases or that simply duplicated other articles. It is quite possible that some papers of significance have been overlooked in spite of careful search of American literature.

FUNGOUS DISEASE

Disease of plants has been defined in several ways. Herein, disease is considered to be any abnormal physiological condition that is harmful to a plant. Disease that results from the presence and activity of a fungus is considered to be a fungous disease. Such diseases are usually classed as infectious diseases, since the causal agent in its normal process of reproduction forms specialized cells or groups of cells that can be disseminated by various agents to other plants of the same species, and cause disease.

Plants give evidence of disease by means of symptoms. Most people are more concerned about these expressions of disease, than about the disease itself. In forest and shade trees, frequently the symptoms of disease are the defects that make the afflicted trees of little or no value to man. For instance, death of the leader and associated branches of an ornamental white pine may disturb the owner of the tree very much and be his greatest concern. However, the dead portions may be only one of the symptoms of root trouble and a direct result of the inability of the roots to absorb sufficient water and minerals in solution — a situation frequently not understood or appreciated by the average tree owner.

Plant disease is one of nature's ways of maintaining equilibrium or balance in a plant community undisturbed by man. The old are removed and the young vigorous individuals take over. It is a natural process that man cannot defeat. Thus he must live with the situation and modify it to suit his needs. In order to do so, it is essential that man learn as much as he can about plant disease and its control, which is one of the chief justifications for research in the field of plant pathology.

White pine trees are subject to attack by a variety of fungous pests, from the time of seed germination to natural death from cumulative effects of advanced age. Tree diseases may be grouped in many ways. For the purpose of this discourse they will be taken up as follows: seedling diseases and diseases of pines beyond the seedling stage, that is, of established trees. Among the latter the diseases will be grouped so far as possible according to the major effects or presence in the roots, stems, branches, and foliage. However, it should be recognized that disease is a composite effect and consequently cannot be relegated strictly to a single part of a tree even though its most striking effect or appearance may be greatly localized.

DISEASES OF SEEDLINGS

DAMPING-OFF

Natural soils rich in humus are densely populated with living organisms, including a great variety of fungi. Whereas many of these are wholly saprophytic in their nutritional activities, some are facultative forms with strong parasitic tendencies. Thus as seeds germinate their young, succulent, easily-injured tissues are immediately surrounded by a host of organisms prepared to kill and utilize every susceptible tissue they contact. The diseases of these very youngest of plants are frequently designated as damping-off.

Damping-off occurs in the natural environment of the forest soil as well as in the artificial environment of the forest nursery. Perhaps even greater numbers of seedlings die from damping-off in natural stands than in man-made seedbeds. The loss of the latter seedlings usually is of greater concern to man, since he has made a direct investment in the purchase of the seed and the preparation and care of the seedbeds. Therefore, considerable research has been conducted for many years to discover the best means of preventing damping-off in private and public owned tree nurseries.

Damping-off disease of white pine may occur as soon as the hypocotyl emerges from the seed coats, and result in death of the potential seedlings before they emerge from the soil. The disease may not start until the seedlings are erect and one or more weeks old. After the seedlings have formed sufficient primary and secondary xylem to remain erect without depending upon turgidity of the parenchyma cells, the term "damping-off" is usually dropped for the disease and "root-rot" is used. Frequently the same fungi are involved and the same symptoms are in evidence except for the wilting of the stem.

The same species of damping-off fungi of white pine appear to be present generally in most forest and nursery soils. The most common probably are species of Fusarium, Pythium, Rhizoctonia and Botrytis. The soil environment varies with different locations which in turn influences the pathogenic activities of the fungi and their control. Consequently the recommendations for the control of damping-off in seedbeds of eastern white pine have varied. The most successful method of control has been through the use of chemicals in an attempt to eliminate the damping-off fungi in the soil immediately before or at the time of planting the seed. Such materials as sulphuric acid, formaldehyde, and methyl bromide are used with some success.

The following abstracts are of papers or parts of papers concerned wholly or in part with damping-off of eastern white pine.

1

Burns, G. P. 1914. Studies in tolerance of New England forest trees. I. Development of white pine seedlings in nursery beds. Univ. of Vermont and State Agric. Coll. Vt. Agric. Expt. Sta., Bull. No. 178.

Damping-off can be controlled with formaldehyde or sulphuric acid.

2

Cox, R. S. 1953. Etiology and control of a serious complex of diseases of conifer seedlings. Phytopath. 43 (9) :469.

A disease complex consisting of damping-off, root-rot, stem canker and needle blight was a serious limiting factor in production of conifer seedlings, including eastern white pine, at Lincoln, Delaware. A very successful control program was accomplished by a combination of soil fumigation and foliage sprays. Formulations of the fumigants and sprays are given. The primary fungus involved was *Cylindrocladium scoparium.*

3

Deam, C. C., et al. 1928. Report of the Division of Forestry. 9th Annual Report, Dept. Conserv., State of Indiana for 1927. Pp. 72-90.

A loss of 10 to 30 per cent of coniferous seedlings, including white pine, was experienced from damping-off. Experimental seed beds were established to test control measures. Heat sterilized sand as a germinating medium and later as a mulch gave no beneficial results. The addition of woods dirt for subsurface and for mulch reduced damping-off and gave more sturdy seedlings. Formaldehyde gave inconsistent results. Bordeaux checked damping-off quite noticeably. (The results obtained with the use of sterilized sand and natural woods dirt are contrary to the experience of many other workers in the control of damping-off.)

4

Eliason, E. J. 1938. Buckwheat as a factor in the root rot of conifers. Phytopath. 28:7.

Root rot occurred during warm periods in a transplant area of the Saratoga Nursery, Saratoga, New York, in soil where buckwheat had been used for several successive years as a cover crop. Fusarium was isolated from the contaminated soil. White pine was of intermediate susceptibility. Infected soils caused damping-off and root rot of 1-year-old seedlings. Control consisted of avoiding contaminated soil for susceptible coniferous species and early planting to avoid warm soil temperatures.

5

Hansen, T. S., W. H. Kenety, G. H. Wiggin and E. C. Stakman. 1923. A study of the damping-off disease of coniferous seedlings. Minn. Agric. Expt. Sta. Tech. Bull. 15.

Seed sown in early summer is less subject to damping-off than that sown in early spring. Shallow planting, half shade, sphagnum mulch, dense planting up to 300 seed per square foot, and a one inch crown of the bed surface lessened the disease. Damping-off is greater in clay than in peat or sand. Amount of water, within limits of good nursery practice, does not affect disease materially. One-fourth ounce of sulphuric acid per square foot of soil surface applied at sowing time reduced damping-off. The disease affected

seedlings under 4 weeks of age. No control for Fusarium was found. Fungi involved were: Fusarium, Pythium, Rhizoctonia, Botrytis, and possibly Alternaria.

6

Hartley, Carl. 1921. Damping-off in forest nurseries. U. S. Dept. Agric., Bur. Plt. Industry, Bull. 934.

A detailed discourse on damping-off of conifers, the effects on the various hosts, and the influencing factors. A table comprised of reports from various sources indicates *Pinus strobus* as ranging in susceptibility from non-susceptible to more susceptible than the average for other conifers.

7

Hartley, C., T. C. Merrill, and A. S. Rhoads. 1918. Seedling diseases of conifers. Jour. Agric. Res. 15 (10) :521-558.

This is a detailed discussion of seedling tree diseases, particularly damping-off. *Corticium vagum* B. and C. (common American Rhizoctonia) is given as a cause of damping-off of eastern white pine seedlings. It is also mentioned as a cause of needle-killing of white pine.

8

Lentz, A. N. and J. W. Andresen. 1956. How to grow evergreen forest trees from seed. Coll. Agric. Rutgers Univ.-State Univ. of New Jersey, Leaflet 161.

Instructions for the planting and care of nursery beds for conifers including white pine are given. For the control of damping-off the use of Ferbam is suggested at the rate of 2 tablespoonsful per gallon of water applied at rate of one pint per square foot as soon as the seeds are planted. Repeat the treatment when 50 percent of the seeds have germinated, and at 3-week intervals until September 1. Methyl bromide used to control weeds in the nursery beds will aid in the control of damping-off. (An instructive leaflet for nurserymen.)

9

Smith, D. M. 1951. The influence of seedbed conditions on the regeneration of eastern white pine. Connecticut Agric. Expt. Sta. Bull. 545.

The only fungi which caused primary damage to seedlings in the old-field stand of white pine used as experiment areas were those causing damping-off and snow mold. Most all isolated seedlings beneath dense slash piles damped-off quickly. Losses by damping-off were relatively unimportant under more favorable conditions. Losses were more common in the shade than in the open, and in part because of close spacing. A few of the vigorous seedlings were killed by the snow mold fungus. A few seedlings on excessively moist areas died of unidentified root-rot fungi. Mycorrhizae were present on most seedling roots within a few weeks after germination.

10

Smith, L. F. 1940. Factors controlling the early development and survival of eastern white pine (*Pinus strobus* L.) in Central New England. Ecol. Monographs 10 (3) :371-420.

One of the several factors discussed is damping-off. The records indicate that losses by this disease under natural conditions are important only in weak plants growing in heavy shade. The low light, high relative humidity, and longer period of seedling succulency apparently favored the pathogenic organisms.

11

Spaulding, Perley. 1908. Treatment of damping-off in coniferous seedlings. U. S. Dept. Agric. Bur. Plt. Industry. Circ. No. 4.

This paper discusses the early use of chemicals for the control of damping-off. A copper-lime formulation proved effective for 7 species of conifers including eastern white pine.

12

Spaulding, Perley. 1914. The damping-off of coniferous seedlings. Phytopath. 4 (2) :73-85.

Damping-off is caused by several widely different fungi under such a range of conditions that no rule for control can be devised for general application. Pretreatment of soil prior to sowing is effectively accomplished with formalin (1 oz. to 1 gal. H_2O), sulphuric acid (1 oz. to 1 gal. H_2O) and dilute ammonium copper carbonate. Poor quality of seed favors damping-off.

13

Wiant, J. S. 1929. The Rhizoctonia damping-off of conifers, and its control by chemical treatment of the soil. Cornell Univ. Expt. Sta. Memoir 124.

The results of 3 years of study of damping-off of coniferous seedlings grown at Ithaca, N. Y. and Keene, N. H. are reported. Eastern white pine was one of the species studied. It was concluded that a single treatment at the time of seeding with liquid applications of aluminum sulfate, mercuric chloride, Semesan, sulfuric acid or Uspulun, or with dry applications of aluminum sulfate, Bayer 11-6, mercuric chloride, or mercurous chloride are equally effective in controlling damping-off of norway spruce, red pine and white pine. The rate of application is suggested for each material. The results indicate that some of the chemical agents may have a favorable brief residual effect.

14

Wycoff, Hugh B. 1955. Methyl bromide fumigation of an Illinois nursery soil. Jour. Forestry. 53 (11) :811-813.

At the Mason State Tree Nursery use of green manure is considered good nursery practice but damping-off losses are high for red and white pine seedlings. Soil fumigation with methyl bromide eliminates damping-off losses. The fumigant can be used safely by following the manufacturer's instructions. Its use reduced otherwise seeding rates by 50 per cent and resulted in proper uniform density in seed beds. Seedling growth in the fumigated beds was greater. Fumigant dosage per 100 square feet averages 1.5 pounds for satisfactory results. Method of application in the Mason Nursery is described.

ROOT ROT

Root rot of eastern white pine seedlings may overlap the damping-off disease. As the term "root rot" is used in this paper, the diseased seedlings are understood to be at least several weeks old and with sufficient xylem to stand erect when turgidity is lost. Seedling root rot also refers to older seedlings retained in the transplant beds for one or two years.

Root rot seems to be less prevalent than damping-off and occurs sporadically. Studies of the disease are related to particular cases. In addition to the fungi that cause damping-off, a few fungi are associated specifically with root rot. Since the pathogenic fungi occupy the soil, control measures for root rot and for damping-off are somewhat similar.

The following abstracts are from papers concerned in whole or in part with root rot of eastern white pine reproduction.

15

Anonymous. 1955. White pine root rot control studies give promising results. Forest diseases. Ann. Report, Lake States Forest Expt. Sta., Forest Service. Pp. 25-26.

Root rot of white pine seedlings was present in the Chittenden Nursery in Michigan. Experimental control was accomplished by use of 2 lbs. of methyl bromide per 100 sq. ft. or 1.5 oz. of 40 per cent formaldehyde per sq. ft. The cause of the rot was not known.

16

Anderson, Ralph L. 1956. White pine root rot control studies continue to give promising results. Forest diseases. Annual Report, Lake States Forest Expt. Sta., U. S. Dept. Agric. Forest Service. P. 18.

A serious root rot of white pine nursery stock appeared in the Chittenden Nursery in Michigan. The cause was unknown but thought to be a fungus, a nematode, or a fungus-nematode complex. Damage has been reduced by applying, prior to seeding, 1½ ounces of formaldehyde per square foot or 1.6 ounces of methyl bromide (MC-2) per 100 square feet. Tests indicate that MC-2 is also effective in transplant beds.

17

Anderson, R. L., D. D. Skilling, and E. D. Clifford. 1956. Nursery root disease control by soil fumigation. Lake States Forest Expt. Sta. U. S. Dept. Agric., Forest Service, Tech. Notes No. 449.

White pine stock from 1-0 seedlings to 2-2 transplants are seriously affected with root rot in the Chittenden Nursery in Michigan. The cause probably involves a fungus, a nematode, or a fungus-nematode complex. Good control has been accomplished by application of methyl bromide (MC-2) 2 lbs. per 100 sq. ft. supplemented with Parzate foliar spray. Methyl bromide, methyl bromide plus Fermate, and formaldehyde (40 per cent commercial) at 1.5 oz. per sq. ft. have given good control of the root disease. In control beds equal size or heavier seedlings result even when density is increased.

18

Crandall, B. S. 1938. A root and collar disease of pine seedlings caused by *Sphaeropsis ellisii*. Phytopath. 28 (3) :227-229.

Young white pines, 5 or 6 years old, from Wisconsin displayed the following symptoms of disease: rot from root collar to below soil line; no resin exudation or infiltration into the xylem; invaded bark tissue deep red with black streaks extending into the xylem. *Sphaeropsis ellisii* Sacc. was isolated from diseased tissue. This fungus is a common cause of twig die-back disease of conifers.

19

Crandall, B. S., G. F. Gravatt, and M. M. Ryan. 1945. Root disease of Castanea species and some coniferous and broadleaf nursery stocks, caused by *Phytophthora cinnamomi*. Phytopath. 35 (3) :162-180.

The fungus was reported from a nursery in Maryland growing eastern white pine. (This detailed discussion of the pathogen and its effects on nursery stock of many tree species, is not concerned in any major degree with white pine reproduction, but does report white pine as a host. The discussion of the pathogen is detailed and excellent.)

20

Eliason, E. J. 1938. Buckwheat as a factor in the rootrot of conifers. Phytopath. 28:7.

See Abstract No. 4.

21

Hord, H. H. V. and D. A. Quirke. 1955. Province of Quebec. Annual Report, Forest Insect and Disease Survey. Canadian Dept. Agric. Forest Biol. Div. Sci. Service. Pp. 56-69.

Armillaria mellea has been found attacking 21 species of deciduous and coniferous trees including eastern white pine. The fungus was isolated from dead white pine seedlings in 2-year-old plantations. The fungus appears of more consequence in plantations than in natural stands.

22

Smith, D. M. 1951. The influence of seedbed conditions on the regeneration of eastern white pine. Conn. Agric. Expt. Sta. Bull. 545.

See Abstract No. 9.

23

Wean, R. E. 1937. The parasitism of *Polyporus schweinitzii* on seedling *Pinus strobus*. Phytopath. 27 (12) :1124-1142.

A physiological and pathological study of white pine seedlings inoculated with *Polyporus schweinitzii* showed the fungus able to parasitize roots of the seedlings. It thus might be spread by nursery stock. Parasitism increased with the alkalinity of the nutrient solution and the reduction of phosphorus. Infected roots were short and discolored. Hyphae penetrated through living cortical cells. The fungus is known to cause root rot in young white pines planted for only 19 years.

24

Weir, J. R. 1915. Observations on *Rhizinia inflata*. Jour. Agric. Res. 4 (1) :93-95.

See Abstract No. 65.

SNOW MOLD

Snow mold or snow blight of conifers is caused by the ascomycete fungus *Phacidium infestens* Karst. It occurs in nurseries and occasionally in very young plantations. The fungus probably is disseminated, at least locally, by ascospores and microsclerotia. Once established, when proper conditions occur it spreads by direct extension of the

mycelial mass beneath the snow. It may cause serious loss of seedlings in crowded seed beds and in natural stands.

The following abstracts are from papers concerned in whole or in part with the snow blight of white pine.

25

Faull, J. H. 1929. A fungus disease of conifers related to the snow cover. Jour. Arnold Arbor. 10 (1):3-8.

The disease is caused by the fungus *Phacidium infestens* and occurs in the heavy snow cover areas of Ontario, Quebec, and northeastern United States. In nursery beds it occurs beneath the snow, killing coniferous seedlings in circular patches as much as 2 feet in diameter. Needles turn brown and those of white pine drop during the following summer. It may cause serious loss in nurseries. Control is accomplished by sanitation and fall spraying with strong lime-sulphur.

26

Faull, J. H. 1930. The spread and the control of *Phacidium* blight in spruce plantations. Jour. Arnold Arbor. 11 (3):136-147.

Whereas this paper is concerned more specifically with the disease of spruce, the statement is made that the fungus found on white spruce spreads by contact to other conifers including white pine. The fungus causing the disease on balsam fir also can spread directly to white pine and other conifers.

27

Korstien, C. F. 1923. Control of snow mold in coniferous planting stock. Jour. Agric. Res. 24 (9):741-747.

At the Cottonwood Nursery snow-mold fungi caused greater loss of nursery stock than any other factor. In the winter of 1920-1921, white pine seedlings of age class 2-1 suffered 60 per cent kill with the remaining 40 per cent showing injury. The disease is controlled by keeping the snow from pressing directly upon the seedlings through the installation of protective frame work.

28

Smith, D. M. 1951. The influence of seedbed conditions on the regeneration of eastern white pine. Conn. Agric. Expt. Sta. Bull. 545.

See Abstract No. 9.

MYCORRHIZA

Mycorrhizae are structures consisting of intimately related root and fungus tissues with a more or less orderly arrangement in respect to each other. Their abundance, presence or even absence on tree roots apparently is influenced indirectly by soil fertility. *Pinus strobus* is one of the four pines on which the mycorrhizae have been studied in detail. Even so, the exact significance of the mycorrhizal relationship is still controversial among scientists concerned with research in that field. The structures appear so early in the life of seedlings and are so constantly associated with tree roots in the nursery, forest, and natural soils in greenhouse culture, that they must have some significance in the physiological functions of the fungus and tree associates.

In the literature, statements occur that indicate mycorrhizae are harmful to trees; that they are essential to the best health of trees; and that they may be neither harmful nor beneficial. Perhaps each of these views is correct, depending upon the total environment within which the fungus and tree are growing.

The topic of mycorrhiza is included in this paper because mycorrhizae are common structures of white pine roots and by some biologists are considered to represent a form of parasitism. There is a vast amount of literature concerned with mycorrhizae. A few publications that refer, at least in part, to *Pinus strobus* are included here. Within such publications only brief reference may be made to white pine. In that case only such parts are abstracted or summarized.

29

Anonymous. 1930. Needle blight of white pine. Annual Rept. to the Legislature, New York State Conserv. Dept. 20th Annual Report. Legislative Doc. 38:200-202.

See Abstract No. 230. (Mycorrhizae, root troubles, and needle blight.)

30

Doak, K. D. 1934. Fungi that produce ectotrophic mycorrhizae of conifers. Phytopath. 24 (1) :7.

Pinus strobus was one of several coniferous species studied. Under controlled tests ectotrophic mycorrhizae developed on the roots of eastern white pine in combination with *Boletus granulatus, Boletinus pictis, Cantharellus cibarius, Amanita muscaria, Russula lepida,* and *Scleroderma vulgare.*

31

Hatch, A. B. 1936. The role of mycorrhizae in afforestation. Jour. Forestry. 34 (1) :22-29.

Seedlings of eastern white pine were used in this study. They were grown in freshly collected prairie soil under controlled conditions, half of the cultures

being inoculated with mycorrhizal fungi. With time the pines in the inoculated pots became deep green and grew rapidly. The controls were short and chlorotic. Other checks were made. As a result of all the observations it was indicated that: white pine seedlings grown in prairie soil did not obtain sufficient nutrients to support normal growth when mycorrhizal fungi were absent; mycorrhizal fungi constitute the specific biological factor which is necessary for the survival of trees in prairie regions. Ways of making practical use of this information in afforestation in prairie regions are pointed out.

32

Hatch, A. B. 1937. The physical basis of mycotrophy in Pinus. Black Rock Forest. Bull. No. 6.

This study of mycorrhiza involved eastern white pine seedlings as well as other members of the genus Pinus. A few of the significant conclusions are: ectotrophic mycorrhizae are not special adaptations for acquiring nitrogen; mycorrhizal development is inversely proportional to soil fertility; mycorrhizal roots are the more efficient in absorbing mineral salts from infertile soils; mycorrhizal fungi are often more exacting in their site environments than the trees with which they are associated; mycorrhizae rarely occur in fertile soils with abundant dissolved nutrients, but long-root tips function chiefly in absorption; and as availability of nutrients decrease, mycorrhizal short-roots do more and more absorption and finally become the only organs of absorption. (An excellent study of mycorrhiza.)

33

Hatch, A. B. and C. T. Hatch. 1933. Some hymenomycetes forming mycorrhizae with *Pinus strobus* L. Jour. Arnold Arbor. 14:324-334.

Under controlled experiments 12 fungi formed typical ectotrophic mycorrhizae with eastern white pine: *Lactarius chrysorheus* Fr., *L. deliciosus* Fr., *Amanita muscaria* (L.) Fr., *Boletus castaneus* Bull., *B. bovinus* Fr., *B. luteus* (L.) Fr., *B. granulatus* L., *Boletinus porosus* (Berk.) Peck, and 4 isolates of *Mycelium radicis*.

34

Hatch, A. B. and K. D. Doak. 1933. Mycorrhizal and other features of the root systems of Pinus. Jour. Arnold Arbor. 14 (1) :85-99.

Ectotrophic mycorrhizae are well-defined morphological organs consisting of "short roots" and a fungus that are constantly arranged in an orderly manner with reference to each other. Only in autumn after elongation of rapidly growing "long roots" has nearly ceased, do tips of eastern white pine frequently acquire mycorrhizal structure. In short roots the multiple tips represent a greatly accelerated development which increases the absorbing surface many times. Investigations should recognize that anatomically, morphologically, and probably physiologically, "short roots" differ from "long roots."

35

Kelley, A. P. 1950. Mycotrophy in plants. Chronica Botanica Company. Waltham, Mass.

This is a series of lectures on the biology of mycorrhizae and related structures in which mycorrhiza of white pine is referred to and commented upon briefly. (An excellent reference text.)

36

McArdle, R. E. 1932. The relation of mycorrhizae to conifer seedlings. Jour. Agric. Res. 44 (4):287-316.

Studies of mycorrhizae included their successful formation on roots of white pine under controlled conditions in synthesis with *Tricholoma personatum, Lycoperdon gemmatum, Clitocybe rivulosa* var. *angustifolia* and *C. diatreta.* Mycorrhizae were formed in the presence of nitrogen supplied by inorganic and organic compounds, as well as in the absence of nitrogen. It appeared as though seedlings assimilated some nitrogen from inorganic compounds even when mycorrhizal fungi were absent, but were unable to secure it from complex organic compounds even in the presence of mycorrhizae. No conclusive evidence was obtained to show that mycorrhizae were either helpful or harmful to white pine seedlings.

37

McComb, A. L. and J. E. Griffith. 1946. Growth stimulation and phosphorus absorption of mycorrhizal and non-mycorrhizal northern white pine and douglas fir seedlings in relation to fertilizer treatment. Plant Physiol. 21:11-17.

Two-year-old seedlings of white pine grew satisfactorily in O'Neill soil inoculated with coniferous humus containing mycorrhizal fungi. In uninoculated soil fertilized with phosphorus, white pine seedlings formed mycorrhizae and made satisfactory growth. The formation of mycorrhizae in fertilized, uninoculated plots of white pine and the difference in structure of the mycorrhizae, as contrasted with some of those forming on seedlings from inoculated plots, suggests the presence of a fungus in the soil capable of forming mycorrhizae and stimulating the seedlings when either or both it and the seedling was first stimulated by phosphorus.

38

Mitchell, H. L., R. F. Finn and R. O. Rosendahl. 1937. The relation between mycorrhizae and the growth and nutrient absorption of coniferous seedlings in nursery beds. Black Rock Forest Papers 1 (10):58-73.

This is a study conducted in outdoor, specially prepared seed beds, using white pine and red spruce. The results of this carefully conducted study indicate that: benefits attributable to mycorrhizae vary inversely as the concentration of readily available mineral nutrients in the soil; with appropriate inoculum and environment, ectotrophic mycorrhizae occur on and are beneficial to coniferous seedlings in a wide range of nutrient environment, except the most fertile or artificially maintained soils; and seedlings lacking mycorrhizae are unable to exist in very infertile substrates.

39

Smith, D. M. 1951. The influence of seedbed conditions on the regeneration of eastern white pine. Conn. Agric. Expt. Sta. Bull. 545.

See Abstract No. 9.

DISEASES OF PLANTATION AND FOREST TREES

ROOT DISEASES

Root rot is a fungous disease of major importance in white pine trees of all ages. Young plants newly set in transplant beds rich in decaying organic matter may suffer severely. Apparently the vigorus facultative parasites active in the disintegration of organic materials in the soil are able to become established in root tissues injured during the process of digging and replanting. Once established in these tissues, the fungi grow into adjacent live tissue, and finally destroy many of the fibrous roots as well as the bark of the larger roots. Some of the young pines die, others recover slowly.

Careless planting may cause serious root distortion and entanglement which eventually can affect the health of the trees adversely. As their health deteriorates, they become very susceptible to attack by various root rot fungi, one of the most common being *Armillaria mellea* (Vahl.) Quel. This fungus frequently is found in physiologically weakened plantation trees 10 to 30 years of age. Unfavorable soil environments also may render young trees susceptible to attack by root and butt rot fungi. *Polyporus schweinitzii* Fries has been associated with root rot in such trees.

Following thinning operations in young stands, the fungus *Fomes annosus* (Fr.) Cke. is known to become active in the initiation of root and butt rot.

In managed stands, the heavy equipment used during logging operations may cause wounds in the butts and large roots of trees that are left for later harvest. Such wounds are favorable sites for the initiation of decay. Trees of all ages in undisturbed stands are subject to root rot but it appears to be more common in trees reaching maturity or already over mature. Most of the serious root-rot fungi of maturing trees also cause low butt rot. Therefore such trees are subject to windthrow and to breakage somewhat above the root crown. Butt rot, associated with root rot, may result in appreciable cull in the first log, particularly when the causal fungus fails to remain localized and extends its activity many feet upward in the trunk.

The following are abstracts of papers or parts of papers that are concerned primarily with root and butt rot in established trees of all ages beyond that of the nursery seed bed. Some of the fungi also cause disease in nursery plants and others may occasionally be asso-

ciated with trunk rot. Therefore reference to these fungi may appear in other sections also. The following references are arranged alphabetically by author, and in each summary or abstract the one or at least the most important agent of decay is named in order to aid the reader who is concerned chiefly with the fungi involved.

40

Anonymous. 1928. Plant diseases. Report of the Div. of Forestry. 9th Annual Report. Dept. Conserv. State of Indiana for 1927. Pp. 72-90.

The shoe string fungus was present in one planting area. Symptoms similar to this disease began to appear in other plantings of white pine, but the presence of the fungus in the latter plantings was not determined. (*Armillaria mellea*).

41

Anonymous. 1929. Experimental control of shoe string fungus. Annual Report to the Legislature. State of New York Conservation Dept. 18th Annual Report. Legislative Doc. No. 38:199-206.

Armillaria mellea was present in a natural white pine stand about 22 years old, where the disease was very severe. Evidences include some resin flow at base of trees, streaking and loosening of the bark near root collar, fan-shape light colored mycelial masses and black rhizomorphs resembling shoe strings. Sporophores appear at base of trees during September through November. Old stumps appear to be sources of the inoculun where the fungus first becomes established. Experimental control of the fungus was begun. It appears that slash removal after logging plus thinning of over-dense pine stands may aid in control. Excellent photographs accompany the article.

42

Anonymous. 1932. Resinosis disease of white and red pine. Annual Report to the Legislature. State of New York Conservation Dept. 21st Annual Report. Legislative Doc. No. 38:164-165.

This briefly states the first planned study of the disease and gives preliminary results. Cause unknown.

43

Anonymous. 1936. Resinosis disease of white and red pine. Annual Report to the Legislature. State of New York Conserv. Dept. 25th Annual Report. Legislative Doc. No. 38:154-155.

Although the disease is lessening, 50 to 65 per cent of the trees have been killed. Two fungi are associated with resinosis, one unidentified, the other *Polyporus schweinitzii*. The disease appears to take effect suddenly and seriously after the first 10 years in the plantations and when the tops have closed in.

44

Anonymous. 1937. Resinosis disease. Annual Report to the Legislature. State of New York Conservation Dept. 26th Annual Report. Legislative Doc. No. 38:128-129.

Infection on two adjacent areas varied from severe when a soil pH of 8.0 existed to absent in soil with a pH of 5.0. Disease was also associated with differences in soil structure, infection being more severe in compact soil

than in relatively loose subsoil, with the pH approximately the same in both soils. A table gives the distribution of *Polyporus schweinitzii* among the plantings, their locations, soil pH, and plant ages.

45

Anderson, R. L., D. D. Skilling and E. D. Clifford. 1956. Nursery root disease control by soil fumigation. Lake States Forest Expt. Sta. U. S. Dept. Agric. Forest Service. Tech. Note No. 449.

See Abstract No. 17. Causal agent unknown.

46

Baxter, D. V. 1937. Development and succession of forest fungi and diseases in forest plantations. Univ. Michigan School of Forestry and Conserv. Circ. No. 1.

White pine is not suitable to plant on worn-out farm lands in southern Michigan, when there is an impervious clay layer two feet or less below the surface. Such trees as young as 10 years are subject to attack by *Polyporus schweinitzii*.

47

Baxter, D. V. 1941. Some resupinate polypores from the region of the Great Lakes. XII. Papers Michigan Acad. Sci. 26 (1940) :107-121.

Fomes annosus causes butt and root rot in *Pinus strobus* as well as in other hosts. The fungus is described in great detail and contrasted with fungi that resemble it. It is possible that the American form of the fungus differs from the European form.

48

Childs, T. W. 1937. Variability of *Polyporus schweinitzii* in culture. Phytopath. 27 (1) :29-50.

P. schweinitzii caused destructive root rot in 20 to 25 year-old plantings of white pine in central New York and thus may continue to be of importance. Originally it was considered of importance mainly in over-mature trees. The fungus is made up of individuals that differ from one another in ability to cause decay as well as in other respects, but there is no evidence of local or host-specialized strains. It is probable that in white pine planted near Springwater, New York, the serious damage is due to site conditions rather than to any special virulence of the fungus.

49

Christensen, C. M. 1938. Root rot of pines caused by *Armillaria mellea*. Phytopath. 28 (1) :5. Abstract.

This fungus was found in the roots of various conifers including white pine growing in natural forests. Infection was more common in dense than in open stands. Trees of all stages of vigor appeared equally susceptible. Damage seemed greatest in stands under 30 years and over 200 years old. Cultural strains of the fungus were isolated but none were found to attack pine seedlings in pure culture. The dying of old, over-mature pine and spruce was attributed chiefly to root rot and drought.

50

Clinton, G. P. 1934. Plant pest handbook for Connecticut. II. Diseases and injuries. Connecticut Agric. Expt. Sta. Bull. No. 358:294.

Fomes annosus was found on roots of eastern white pine. Typical rot normally associated with the fungus was found in roots of white pine as early as 1906 but the sporophores were not found at that time.

51

Crandall, B. S. 1938. A root and collar rot disease of pine seedlings caused by *Sphaeropsis ellisii.* Phytopath. 28 (3) :227-229.

See Abstract No. 18. (*Sphaeropsis ellisii.*)

52

Haddow, W. R. 1933. Disease as a factor in the transition of pine to stable types. Forestry Chronicle 9 (1) :30-35.

Pine when associated with more tolerant species, being unable to reproduce in their shade, ultimately disappears from the stand. Disease causes the death of most of the pines. Root and butt rot fungi (*Armillaria mellea* and *Polyporus schweinitzii,* respectively) although of little importance as wood destroyers, are first to cause break-up of a stand, and destroy most of the trees. Trunk rot fungi (*Trametes pini, P. schweinitzii, Fomes laricis, F. pinicola, F. roseus*) account for great wood loss and are of little importance silvically. Incidence of top rots increases sharply in old stands.

53

Hansbrough, J. R. 1948. Forest disease problems in the Northeast. New York Forester 5 (2) :6-9.

See Abstract No. 195. (*Fomes annosus, Polyporus schweinitzii.*)

54

Hartley, C. 1910. *Fomes annosus* and two species of *Gymnosporangium* on *Juniperus virginiana.* Expt. Sta. Rec. 23:355.

Fomes annosus is reported on the roots of eastern white pine.

55

Haasis, F. W. 1923. Root rot as a factor in survival. Jour. Forestry 21 (5) :506.

In sample plots of white pine in the Biltmore plantations, two trees were uprooted by wind. The roots were decayed by *Fomes annosus.* It is suggested that thinning would result in some drying of the soil and thereby hinder the spread of the fungus.

56

Hedgcock, G. G., G. F. Gravatt and R. P. Marshall. 1925. *Polyporus schweinitzii* Fr. on douglas fir in the eastern United States. Phytopath. 15 (9) :568-569.

Douglas fir plantations near Biltmore, N. C., had trees that showed typical symptoms of decay by *P. schweinitzii.* The sporophores were found at the base of several trees and in association with the typical red brown rot. It is suggested that the fungus probably spread from such conifers as eastern white pine, spruce, fir, and hemlock.

57

Hepting, G. H. and A. A. Downs. 1944. Root and butt rot in planted white pine at Biltmore, North Carolina. Jour. Forestry 42 (3) :119-123.

In previously thinned white pine plots 75 per cent of the trees had root and butt rot. In unthinned stands only 4 per cent were butt rotted. The major agent was *Fomes annosus. Polyporus circinatus* and *P. schweinitzii* were of less importance. Decay fungi gained entrance through roots that died as a result of strangling associated with poor planting and other causes. The larger amount of butt rot by *F. annosus* may be due to its build-up in stumps of previous thinnings. (A careful study of these important diseases in a plantation.)

58

Hord, H. H. V. and D. A. Quirke. 1955. Province of Quebec. Annual Report, Forest Insect and Disease Survey, Canadian Dept. Agric. Forest Biol. Div. Sci. Service. Pp. 56-69.

See Abstract No. 21. (*Armillaria mellea.*)

59

Lorenz, R. C. and C. H. Christensen. 1937. A survey of forest tree diseases and their relation to stand improvement in the Lake and Central States. U. S. Dept. Agric., U. S. Forest Serv., Reg. 9, Univ. Minnesota. Processed.

Armillaria mellea usually injures only those trees already weakened by drought, fire and other causes, but it will attack and kill otherwise healthy trees of all ages, but only in isolated cases. *Fomes pini* is important in the decay of white pine in the Lake States, entering usually through the branches.

60

Marshall, R. P. 1948. A white root rot which merits study as a possible cause of white pine blight. Scientific Tree Topics 1 (9):66-68.

December, 1947, a buff colored fungus mycelium was found in the duff under blighted white pines that were dwarfed and chlorotic. The hyphae extended to the pine roots which disclosed a white rot condition. The fungus was tentatively identified as *Corticium galactinum*. In 1948 the fungus was found in parts of Connecticut, New York, Delaware and Pennsylvania beneath blighted white pine. A more thorough study was anticipated.

61

Spaulding, P. 1937. Root rots of conifers. Massachusetts Forest and Park Assoc. Tree Pest Leaflet No. 18.

This is a condensed semi-technical discussion of root rots of conifers caused by *Fomes annosus* and *Polyporus schweinitzii*. Eastern white pine is one of the hosts listed. Symptoms of disease, the fungi, their life histories, spread and control are given.

62

Stoddard, E. M., A. D. McDonnell and H. W. Hicock. 1939. *Fomes annosus* on conifers in Connecticut. Plant Disease Reporter 23:385-386.

In 1928 *Fomes annosus* was found on roots of eastern white pine in a natural stand about 75 years old and in a 21-year-old plantation. In 1938 following the September hurricane, 7 species of conifers including *Pinus strobus* were found to be infected with *F. annosus*. In a 100-acre plantation of Norway spruce and white pine, the latter seemed to be the more generally and seriously affected.

63

Wahlenberg, W. G. 1955. Six thinnings in a 56-year-old pure white pine plantation at Biltmore. Jour. Forestry 53 (5):331-339.

Fomes annosus infection of white pine on the Biltmore Estate has been traced to unnatural root arrangement from poor planting. Its buildup is linked with frequent thinning. The fungus is less abundant in stands of natural origin and in unthinned portions of plantations. Depletion of soluable carbohydrates in slowly dying trees leaves the dead roots a less favorable medium for fungus growth. Up to 1955 the damage in the thinned plot was minor.

64

Wean, R. E. 1937. The parasitism of *Polyporus schweinitzii* on seedling *Pinus strobus*. Phytopath. 27 (12) :1124-1142.

See Abstract No. 23.

65

Weir, J. R. 1915. Observations on *Rhizinia inflata*. Jour. Agric. Res. 4 (1) :93-95.

Evidence is presented that suggests *Rhizinia inflata* (Schaff) Sacc. to be capable of killing roots of 3- and 4-year-old seedlings of white pine. The fungus is distributed throughout much of the forest area of the United States.

66

York, H. H. 1938. Some diseases in forest plantings of white pine and red pine in western New York. Phytopath. 28 (1) :22. Abstracts.

The damage from *Polyporus schweinitzii* and a resinosis in white pine planted for 20 to 30 years is so severe that it is doubtful whether the trees covering an area of more than 1000 acres will reach maturity. The disturbances are most destructive in soils of a high pH and colloidal content with slow or poor duff humidification.

67

York, H. H., R. E. Wean and T. W. Childs. 1936. Some results of investigations on *Polyporus schweinitzii* Fr. Science 84:160-161.

As early as 1928 a resinosis disease was present in certain white pine plantations of central New York State. Investigation disclosed the presence of a grey-black fungus that produced no fruiting stage in culture. Resinosis was most severe where the pH of the soil was 6.0 or above and the colloidal content 52 per cent or more. Although sporophores of *Polyporus schweinitzii* appeared in stands where resinosis was severe, the fungus did not seem to be the direct cause of resinosis.

Root rot by *P. schweinitzii* was extremely severe in plantations with and without resinosis. In such plantations there was 21 per cent more calcium in the upper soil layer than where the fungus was absent. Infected trees were deficient in calcium in comparison with healthy trees. Possibly the fungus renders calcium unavailable to trees. Culture studies indicate differences among isolates of the fungus. The isolate from the heavily infected plantations in central New York appeared to be of local origin. (An important study of resinosis disease.)

STEM DISEASES

Canker Diseases
(Other than blister rust canker)

"Canker" of woody plants usually refers to a localized area of diseased bark characterized by the presence of callus, necrosis of the phloem and sometimes of the underlying cambium, caused by an external influence. The causal factor may be infectious or non-infectious.

Canker diseases of twigs and stems caused by fungi are relatively unimportant in eastern white pine, except for cankers caused by the blister rust fungus. Most cankers are associated with young reproduction and trees of pole size.

The most common cankers and perhaps the most conspicuous are: 1, the resinosis trunk canker of saplings; 2, the basal girdling canker of young transplant stock and natural reproduction. Neither of these canker types have had positive proof presented that they are of fungus origin. Because the causes are unknown, it is a good precaution to be aware of their presence and possible association with fungus pathogens.

The basal girdling cankers of transplant stock are associated with certain environmental factors and with several fungi, one of which is quite constantly present. Plants with basal cankers are frequently found in ant-infested areas and some foresters have the opinion that the ants are the direct cause of a basal canker. There is some evidence that the ants simply are disseminators of the spores of a pathogenic fungus rather than the primary cause of the basal injury. Tansplant stock set in heavy clay soils sometimes develops basal cankers the first season of planting if there are alternating periods of rain and dry weather. When the loose soil about the base of the plants becomes wet, winds may cause the stems to move and compact the adjacent soil into a sharp collar about the root crown. Upon drying, this compact ring of clay becomes extremely hard. As the natural breezes move the stems about, the ring of hard clay wears the tender bark away, allowing fungi to become established in the injured bark tissues and cause cankers.

The resinosis trunk canker is different than the basal resinosis canker described by H. H. York and his associates (Abstracts Nos. 66, 67). The first visible evidence of the trunk canker is a number of minute droplets of resin that ooze from a localized area of the bark, approximately at breast height. The resin flow increases until the bark of the affected area is almost covered. Meanwhile enlargement may occur on the trunk opposite the canker as the trunk is slowly girdled. Eventually death occurs. Wood decay is not associated with the resinosis canker. Efforts by research workers at the State University College of Forestry have failed to isolate any fungus consistently from the diseased bark or wood beneath. The fungus *Biatorella resinae* (Fries) Mudd, is usually present on the resin that covers the diseased bark, but it is not considered to be pathogenic. Cankers were not formed when cultured tissue of this fungus was introduced into living white pine bark. The canker is associated with

artificially established stands and appears when the trees are approximately 20 to 25 years old. It is present in New York, and recently a similar cankering of white pine has been reported from New England.

Occasionally reference is made to cankers associated with fruit bodies of *Fomes pini* on white pine trunks. The writer does not consider the sunken necrotic areas that sometimes surround the sporophores to be cankers, as the term is generally used, even though they have the appearance of cankers.

The following abstracts are from papers that are concerned wholly or in part with cankers of eastern white pine, whether of the trunk or branches, but not including cankers by the blister rust fungus.

68

Ayers, T. T. 1941. *Biatorella resinae:* The perfect stage of *Zythia resinae*. Mycologia 33 (1):130-135.

The fungus occurs on pitch flow from injured bark of several conifer species, including eastern white pine. Inoculation tests on 6 vigorous young white pine in a greenhouse failed to indicate the fungus to be parasitic.

69

Beattie, R. K. 1933. Diseases threatening ornamental and forest trees. Jour. Econ. Ent. 26 (3):621-624.

Reference only is made to "a canker disease attacking the crown and upper roots of the red and white pines in an alarming fashion" in certain plantations of central New York. (This is the resinosis disease described by H. H. York. See Abstract No. 66.)

70

Cash, E. K. and R. W. Davidson. 1940. Some new species of ascomycetes on coniferous hosts. Mycologia 32 (6):728-735.

This paper describes several new species of fungi, one of which is found upon a fungus *Scoleonectria scolecospora* (Bref.) Seaver, which in turn was growing on twigs of *Pinus strobus*.

71

Davidson, A. G. 1954. Decline in vigor of white pine. Canadian Dept. Agric. Ann. Rept. Forest Insect and Disease Survey, p. 24.

An unknown disease is present on eastern white pine in central New Brunswick and the Maritime region. The most conspicuous symptom is excessive pitch flow from cracks in desiccated patches of the bark. Crowns become thin, apparently followed by chlorosis and stunted needles. (These symptoms are similar to those reported by the writer in the introduction to this section, in describing a resinosis trunk disease of planted white pine in central N. Y.)

72

Diller, J. D. 1943. A canker of eastern pines associated with *Atropellis tingens*. Jour. Forestry 41 (1):41-52.

This fungus was found in 20 states on 17 host species. On eastern white pine it was reported only from Virginia, and is probably of little if any importance on this host. (The disease is thoroughly discussed and well illustrated on eastern hard pines.)

Fink, B. 1911. Injury to *Pinus strobus* caused by *Cenangium abietis*. Phytopath. 1 (6) :180-183.

See Abstract No. 244.

74

Fitzpatrik, H. M. 1920. Monograph of the Coryneliaceae. Mycologia 12 (4) : 206-237.

Caliciopsis subcortioalis (Cooke and Ellis) comb. nov. is described. Its mycelium in pine is considered to be parasitic upon *Pinus strobus* in eastern North America, causing small bark cankers. Other pine hosts are also listed.

75

Gilman, J. C. and G. L. McNew. 1940. Fungi associated with tree cankers in Iowa. II. Diaporthe, Apioporthe, Cryptodiaporthe, Pseudovalsa, and their related conidial forms. Iowa St. Coll. Jour. Sci. 14 (2) :129-144.

The fungus *Phomopsis conorum* (Sacc.) Died. is described. It was found on eastern white pine during 1933 in 3 counties in Iowa.

76

Graves, A. H. 1913. Notes on diseases of trees in the southern Appalachians. I. Phytopath. 3 (2) :124-139.

See Abstract No. 245. (*Coccomyces pini.*)

77

Graves, A. H. 1914. A preliminary note on a new bark disease of the white pine. Mycologia 6 (2) :84-87.

A basal canker occurs on young eastern white pine that girdles the stem and causes premature death. Among the several fungi isolated from the cankers, a species of Fusicoccum was the most general. Proof of pathogenicity of the fungus is lacking.

78

Groves, J. W. 1946. North American species of Dermea. Mycologia 38 (4) :351-431.

This is a very detailed discussion of species of Dermea. Little is known concerning parasitism of most of the species. The species are host specific and some occur on recently killed twigs, indicating at least weak parasitism. *Dermea pinicola* sp. nov. is described. It is specific to *Pinus strobus* and has been found in Ontario, Canada and Vermont.

79

Groves, J. W. 1952. The genus Tympanis. Canadian Jour. Botany 30 (5) :571-651.

This is a taxonomic study of the genus Tympanis. The host specificity of the species suggests at least weak parasitism. Three species are listed as present on eastern white pine: *T. confusa* Nyl., *T. pithya* (Karst.) Karst. and *T. hypopodia* Nyl. for Pinus species generally.

80

Haasis, F. W. 1917. Dying of young pines in circles about anthills. Jour. Forestry 15 (6) :763-771.

Basal cankers of young eastern white pine are associated with the presence of ants, which may act as carriers of the fungus *Fusicoccum abietinum* (Hrtg.) Prill. and Del. that is commonly isolated from the cankered bark.

81

Hahn, G. G. 1957. Phacidiopycnis (Phomopsis) canker and dieback of conifers. Plt. Dis. Rep. 41 (7):623-633.

In the United States the canker-dieback disease caused by *Phacidiopycnis pseudotsugae* (M. Wils.) Hahn the imperfect stage of a new species *Phacidiella coniferarum* Hahn, occurs only in the Northeast where it is now identified with the "Phoma disease" of eastern white pine saplings. Infection following controlled inoculation of 8 species of conifers occurred only during autumn and early spring. Damage due to the parasite and control procedures in the Northeast are outlined. The fungus is a wound parasite and may become established in pruning wounds of plantation stock growing on poor sites. (This canker disease is not to be confused with the basal girdling cankers reported as a result of ant injury to young planting stock of eastern white pine.)

82

Hahn, G. G. and T. T. Ayres. 1934. Dasyscyphae on conifers in North America. III *Dasyscypha pini*. Mycologia 26 (6):479-501.

Evidence is presented to show that the *Dasyscypha* associated with cankers of eastern white pine, as well as certain other pines, differs from *D. fuscosanguinea,* and is referred to *D. pini* (Brunchorst) Hahn and Ayres.

83

Hahn, G. G. and T. T. Ayres. 1936. The European larch canker and its relation to certain other cankers of conifers in the United States. Jour. Forestry 34 (10):898-908.

Dasyscypha pini (Brunch.) Hahn and Ayres will parasitize young white pine reproduction on fairly favorable pine sites, causing girdling and killing of branches and stems of small diameter. On stems and branches of 4 inches in diameter a perennial canker is formed. The fungus is known to occur in northern Michigan. At low elevations this disease forms a few scattered cankers which do not cause much injury. (An authentic discussion of several species of Dasyscypha and their related tree hosts.)

84

Hansbrough, J. R. 1934. Occurrences and parasitism of *Aleurodiscus amorphus* in North America. Jour.Forestry 32 (4):452-458.

The fungus *Aleurodiscus amorphus,* usually a saprophyte, may become parasitic and cause a canker disease in certain coniferous hosts, invading the live wood from a saprophytic existence in dead twigs. For the first time *Pinus strobus* is reported as a host. Infection of the eastern pine host was reported from Quebec, Canada.

85

Hansbrough, J. R. 1935. A new canker of red pine, caused by *Tympanis pinastri.* Science 81 (2104):408.

The pathogen is also associated with cankers on *Pinus strobus,* but infection is limited to trees which are greatly weakened through shade suppression, root competition, poor soil or some other similar cause. Occasional cankers on white pine were observed throughout New England and in New York and Maryland. Symptoms of the disease are described.

Hansbrough, J. R. 1936. The Tympanis canker of red pine. Yale Univ. School of Forestry. Bull. No. 43.

The pathogen is of serious consequence only on red pine; however, it does occur occasionally on eastern white pine, but only on trees already weakened by some adverse factor. Thus on white pine the disease is not considered dangerous and might even be beneficial. Inoculum from white pine caused infection in red pine. An excellent illustration of the canker on white pine is shown. (A thorough and excellent coverage of Tympanis canker on red pine.)

87

Hawley, R. C. and S. J. Record. 1916. Do ants kill trees about their colonies? American Forestry 22 (275) :685-686.

Girdling basal cankers that kill young eastern white pines occur in areas harboring ant colonies. The ants are considered to be the direct cause of the disease, attacking trees that shade the colonies. No positive proof is advanced. It is stated that "if fungi or bacteria are responsible, the only plausible means of dissemination is through the agency of ants."

88

Hedgcock, G. G. 1932. Notes on the distribution of some fungi associated with diseases of conifers. Plant Disease Reporter 16 (4) :28-42.

The following fungi are reported on eastern white pine: *Caliciopsis pinea* Peck probably parasitic on twigs; *Coccomyces pini* (A. & S.) Karst. associated with twig blight and bark cankers; *Cytospora pinastri* probably parasitic; *Sphaeropsis ellissii* Sacc., weakly parasitic associated with cankers and dead twigs; *Valsa abietis* Fr. on twigs and bark.

89

Hilborn, M. T. and F. L. Markin. 1938. List of causes of fungus and bacterial plant diseases in Maine to 1936 inclusive. Plant Disease Reporter Supplement 105:1-60.

For eastern white pine, 13 fungus collections are included: *Caliciopsis pinea* Pk., *Calocera cornea* Fr., *Coccomyces* sp., *Coccomyces pini* (Fr.) Karst., *Cronartium ribicola* Fischer, *Cryptosporium pini* Berk. and Curt., *Fomes pini* (Thore) Lloyd, *F. pinicola* (Swartz) Cke., *Lophodermium pinastri* (Schrad.) Chev., *Polyporus schweinitzii* Fr., *Septobasidium pinicola* Snell, *Thelephora laciniata* Pers., *Tryblidiopsis pinastri* (Pers.) Karst. (Even though other than canker pathogens are included, the total list is given and the remaining pathogens are referred to under other topics.)

90

Lohman, M. L. and E. K. Cash. 1940. Atropellis species from pine cankers in the United States. Jour. Wash. Acad. Sci. 30 (6) :255-262.

Two fungi *Atropellis pinicola* Zeller and Gooding and *A. tingens* sp. nov. cause characteristic bark cankers of twigs and stems of *Pinus strobus*. The latter fungus is widely distributed in eastern United States; the former occurred on *P. strobus* in Oregon. Descriptions of the two fungi are given.

91

McCormack, H. W. 1936. The morphology and development of *Caliciopsis pinea*. Mycologia 28 (2) :188-195.

The fungus *Caliciopsis pinea* Peck is common throughout the Northeast and New York. Fruit bodies were found on typical smooth depressed cankers of *Pinus strobus*. (The fungus is described in detail making the paper of special interest to mycologists.)

92

Martin, C. H., Jr. 1920. Diseases of forest trees, ornamentals and miscellaneous plants in the United States in 1920. Reprint from The Plant Disease Bull. Supplement 11.

Cenangium ferruginosum Fr. (*C. abietis* [Pers.] Rehm.) is reported as causing a canker on *Pinus strobus* in Ohio.

93

May, C. 1934. Pine canker. Fifty-second Ann. Report, Ohio Agric. Expt. Sta. Bull. 532:38.

A fungus tentatively identified as *Atropellis pinicola* Zeller and Gooding was associated with canker of *Pinus strobus*. The cankers in Ohio were relatively young, indicating a recent appearance in the area.

94

Overholts, L. O. 1929. Mycological notes for 1926-27. Mycologia 21 (5):274-287.

Valsa and Cytospora species are found on conifers but their parasitic activities are little known. *Valsa pini* (Alb. and Schw.) Fries is common on *Pinus strobus* in the Allegheny region of Pennsylvania. It has been collected from a recently killed sapling, from a sunscald area of a living tree, a dead sapling, an apparent frost canker, and a basal canker.

95

Overholts, L. O. 1930. Mycological notes for 1928-1929. Mycologia 22 (4):235.

Caliciopsis pinea Pk. occurs only on pines in this country and is reported as very common on bark of small trees of *Pinus strobus* in Pennsylvania, sometimes associated with small depressed cankers. It is probably a parasite, since heavily infected small saplings have died.

96

Pierson, H. B. 1955. Bleeding of white pine. Maine, 30th Biennial Rpt. Forest Commissioner, 1953-1954. P. 128.

Resin flow on trunks of eastern white pine, in localized areas for which no cause is known, seems to be on the increase. No permanent effect on the life of the trees was noticed by 1954.

97

Ray, W. W. 1936. Pathogenicity and cultural experiment with *Caliciopsis pinea*. Mycologia 28 (3):201-208.

The fungus causes two different kinds of small cankers upon eastern white pine. This was proven by Koch's postulates procedures. Fruiting forms of the fungus are described and pictured.

98

Snell, W. H. 1922. A new Septobasidium on *Pinus strobus*. Mycologia 14 (2): 55-60.

Septobasidium pinicola sp. nov. is described and illustrated. The fungus occurs only upon the smooth bark of white pines and is wholly epiphytic. (It is included here only because it can be confused with pathogenic bark organisms.)

Snell, W. H. 1929. *Dasyscypha agassizii* on *Pinus strobus*. Mycologia 21 (4): 235-242.

The fungus was found to be very abundant upon eastern white pine, especially on blister rust cankers in certain plantations in northern New York. It is also reported on other coniferous hosts. (This is perhaps the earliest report of the fungus on white pine in the United States.)

100

Spaulding, P. 1909. The white pine blight. Science 29 (753) :911.

See Abstract No. 259. (*Lophodermium brachysporum.*)

101

Stillwell, M. A. and A. G. Davidson. 1953. Maritime Provinces. Canadian Dept. Agric. Ann. Report Forest Insect and Disease Survey, Science Service. Pp. 20-31.

A table of noteworthy diseases lists *Caliciopsis pinea* Pk. on superficial bark cankers of eastern white pine in New Brunswick.

102

Waterman, A. M. 1955. The relation of *Valsa kunzei* to cankers on conifers. Phytopath. 45 (12):686-692.

The fungus is listed from different conifers including eastern white pine. On the basis of stromatal variation, 3 varieties and their pycnidial stages are described. The form found on white pine is given as *Valsa kunzei* var. *superficialis* comb. nov. Excellent photographs of stromatal differences are presented. Bark removal from large cankers, although not practical, was the only effective control discovered. (An authentic report on this fungus.)

103

Wood, J. I., N. E. Stevens and P. R. Miller. 1933. Diseases of plants in the United States in 1932. Plant Dis. Rep. Suppl. 85:65.

Canker of eastern white pine by *Dasyscypha fusco-sanguinea* occurs in several small areas in the Keeweenaw Peninsula from Mohawk to Fort Wilkins and also just south of Calumet, Michigan. It appears to be an aggressive parasite especially on shaded understory trees. (A Dasyscypha was found well established on young natural reproduction in the open on the Keeweenaw Peninsula in 1928 by the present abstractor.)

104

York, H. H. 1938. Some diseases in forest plantings of white and red pine in western New York. Phytopath. 28:22.

See Abstract No. 66. (Resinosis.)

105

Zeller, S. M. 1935. Some miscellaneous fungi of the Pacific Northwest. Mycologia 27 (5) :449-466.

Atropellis pinicola Zeller and Gooding is reported as a parasite of *Pinus strobus,* collected for the first time in Oregon.

White Pine Blister Rust

The blister rust disease caused by *Cronartium ribicola* Fischer at present is the most serious fungous disease of eastern white pine in North America. Many years of study and careful research concerned with the pathogen and its white pine host, has resulted in a great abundance of American literature related to these studies. Some of the literature is repetitious, the same information appearing in different scientific journals, technical bulletins, popular and semi-popular publications. Therefore, this writer deemed it most profitable to restrict the list of abstracted references to published original research projects, and original papers that used previously reported research as a basis for new thoughts and conclusions about this disease on eastern white pine, its cause, and control. Some exceptions have been made, and a few special articles have been included in which only brief reference has been made to the infection of white pine by the blister rust pathogen. Papers now only of historical significance have, for the most part, been omitted.

The following selected references are concerned primarily with the disease of *Pinus strobus* rather than detailed studies of the pathogen. Even though careful search of the literature has been made, it is entirely possible that some worthy references of this nature have been overlooked.

106

Anon. 1940. Density of stocking and damage from blister rust. State of New York, Conserv. Dept. 29th Annual Report. Pp. 113-114.

Eastern white pine stands appear relatively safe from commercial damage by blister rust if stocked uniformly with 2000 trees per acre. The protective border strip in the average swamp or dense woodland may be much narrower than in open land types where large infected ribes bushes are exposed to the wind.

107

Anon. 1955. Influence of microclimate on white pine blister rust infection. Annual Report (for 1955) Lake States Forest Expt. Sta. U. S. Dept. Agric. Forest Service. P. 24.

Announcement of a project relating microclimate and white pine infection by *Cronartium ribicola*. Indications are that under certain localized conditions the microclimate may be unfavorable for infection of white pine and it will be unnecessary to eradicate ribes. (The study is still in progress in 1958.)

108

Anderson, R. L. and D. W. French. 1955. Evidences of races of *Cronartium ribicola* on ribes. Forest Science 1 (1) :38-39.

Spores from 3 species of blister-rust infected white pines, including *Pinus strobus*, were used to induce the rust stage on ribes. Preliminary results based on differing lesions on ribes foliage suggest that races of the fungus exist in America. Their separate effects on eastern white pine have not been tested.

109

Atwood, G. G. 1909. Emergency bulletin on the blister rust of pines and the European currant rust. New York Dept. Agric.

This is one of the early publications on white pine blister rust in North America, and is of historical interest only.

110

Ball, J. C. 1949. Association of white pine with other tree species and ribes in the southern Appalachians. Jour. Forestry 47 (4) :285-291.

Control of fire and blister rust during the past 14 years have aided the establishment of eastern white pine, which is now establishing itself on a variety of sites at high and low elevations. Wild ribes are abundant at the higher elevations. Ribes eradication should be supplemented with forest management practices that will suppress the ribes and also release young white pines. Full productivity of the mixed white pine and hardwood forests will be lost unless timber management is closely integrated with blister rust control.

111

Baxter, D. V. 1923. White pine blister rust in Michigan. Phytopath. 13 (6): 285-286.

The first blister rust infection of white pine in Michigan was found in Oakland County during 1917. Up to 1923, all pine infections in Michigan were traceable to white pine of French origin, rather than from inoculum from infected plants in Wisconsin and Ontario. (Of historical significance only.)

112

Bergeson, E. D. and R. W. Lorenz. 1957. Seasonal effectiveness of 2, 4, 5-T basal sprays for eradicating ribes in white pine blister rust control in Illinois. Jour. Forestry 55 (1) :17-19.

In Illinois, *Ribes missouriense* is of chief concern as an alternate host of *Cronartium ribicola*. Chemical eradication of ribes since 1951 has been accomplished with basal sprays of 2,4,5-T in fuel oil applied during any season of the year. This type of control is more efficient, easier and cheaper than hand pulling.

113

Boomer, S. H. and L. E. Newman. 1950. The Hurlin plantation. A case history. Bur. Ent. and Plt. Quarantine, Div. Plt. Dis. Control.

This is a detailed report of a planting of eastern white pine and its record of infection by *Cronartium ribicola*. The plantation was established in 1915. When first inspected for blister rust in 1926, 211 trees were present, 146 trees being infected. By 1949, 79.14 per cent of all the trees had died from blister rust infection, 24 pines were rust free, 13 of which had never become infected. These rust free trees may have a rust resistant factor, hence certain of these trees are being propagated vegetatively and tested for rust resistance.

114

Boyce, J. S. 1943. Host relationships and distribution of conifer rusts in the United States and Canada. Trans. Connecticut Acad. Arts and Science, 35:365-366.

Many references to *Cronartium ribicola* are listed. The rust in the East ranges from Prince Edward Island to Ontario and Minnesota, south to North Carolina and northern Tennessee. The pathogen is probably a native of Asia.

115

Childs, T. W. and J. L. Bedwell. 1948. Susceptibility of some white pine species to *Cronartium ribicola* in the Pacific Northwest. Jour. Forestry 46 (8) :595-599.

In comparison with native western 5-needle soft pines, *Pinus strobus* was of moderate susceptibility, rating seventh in a list of 10 white pines. The study was done in the West.

116

Clepper, H. E. 1930. White pine blister rust in Pennsylvania. Penn. Dept. Forests and Waters Res. Circ. 2.

This is a brief review of white pine blister rust in America prior to 1930, and particularly in Pennsylvania. It covers in detail control procedures and costs in Pennsylvania.

117

Clinton, G. P. and F. A. McCormick. 1919. Infection experiments of *Pinus strobus* with *Cronartium ribicola*. Connecticut Agric. Expt. Sta. Bull. 214:428-459.

See Abstract No. 236. (A detailed study of needle infection.)

118

Colley, R. H. 1917. Diagnosis white-pine blister-rust from its mycelium. Jour. Agric. Res. 11 (6) :281-286.

By means of two stains applied to infected host tissues, *Cronartium ribicola* can be distinguished from other parasitic fungi by the size of the hyphae and the presence of characteristic haustoria.

119

Colley, R. H. 1918. Parasitism, morphology, and cytology of *Cronartium ribicola*. Jour. Agric. Res. 15 (12) :619-682.

This is primarily a detailed cytological study of the fungus but also touches upon the intimate relation of the fungus to the invaded bark tissues of *Pinus strobus*. (A fundamental study of real importance.)

120

Detwiler, S. B. 1933. Black currant spreads white-pine blister rust. U. S. Dept. Agric. Misc. Publ. No. 27.

This is an early authentic statement on the importance of *Ribes nigrum* L. as a source of inoculum for infection of *Pinus strobus* by *Cronartium ribicola*. The spread of the fungus from ribes to pine and back again is nicely illustrated.

121

Filler, E. C. 1933. Blister rust damage to northern white pine at Waterford, Vermont. Jour. Agric. Res. 47 (5) :297-313.

Data on the effects of blister rust in a merchantable stand of eastern white pine in Vermont are presented. Data on 2226 pines grouped by height and years of exposure to inoculation shows infection by number of trees to range from 0 to 62 per cent, the proportion becoming greater with tree height and increased years of inoculation. Unsuppressed trees were more heavily infected and suppressed trees were killed more quickly. The proportion of total board-foot volume of infected dying or dead trees increased from 8 per cent in 1925 to 23 per cent in 1930. The economic loss in the merchantable stand computed at normal stumpage value of $8 per thousand, amounted to $19.86 per acre in 1930. The increase may reach $139.18 per acre depending on the delay in logging.

122

Heimberger, C. 1955. Blister rust resistance in white pine. Third Northeastern Forest Tree Improvement Conference Proceedings. Pp. 6-11.

This is a brief review of the methods used at Maple, Ontario, to prepare grafts of selected potentially resistant white pines for testing. Certain results are mentioned and their implications are pointed out. The thought is expressed that resistance to blister rust by eastern white pine is inherited as a polygenic character, and that breeding for resistance should be carried out with that as a working hypothesis. (The long experience of Dr. Heimberger in such studies makes this paper of particular value to beginners in similar projects.)

123

Hirt, Ray R. 1936. The progress of blister rust in planted northern white pine. Jour. Forestry 34 (5):506-511.

In newly established plantings of white pine, infected trees may persist 8 years and more after infection by *Cronartium ribicola*. Because the persisting infected trees may produce aeciospores, there is the need of regular inspection for ribes and their eradication. Seven infected trees gave some evidence of rust resistance.

124

Hirt, Ray R. 1938. Relation of stomata to infection of *Pinus strobus* by *Cronartium ribicola*. Phytopath. 28 (3):180-190.

See Abstract No. 249.

125

Hirt, Ray R. 1939. The development of blister rust on young planted northern white pine. Jour. Forestry 37 (12):967-969.

A single exposure of young white pines to telium-bearing ribes for 12 to 24 hours under favorable meteorological conditions resulted in a maximum of 4 per cent of the trees becoming infected. Exposure for a summer season gave 69 per cent infection. Some infected trees were still alive after 11 years. The plantations were afforded protection after initial infection and only 0.5 per cent of the trees showed new infections after 5 years.

126

Hirt, Ray R. 1940. Relative susceptibility to *Cronartium ribicola* of 5-needled pines planted in the East. Jour. Forestry 38 (12):932-937.

A field test of the relative susceptibility of certain native and exotic 5-needled pines to the blister rust pathogen under eastern conditions, showed *Pinus strobus* to be less susceptible than *P. monticola* and *P. flexilis* but more so than 4 other species.

127

Hirt, Ray R. 1942. The relation of certain meteorological factors to the infection of eastern white pine by the blister-rust fungus. New York State Coll. For. Tech. Publ. No. 59.

An extensive study of weather and its influence on eastern white pine in the Northeast is reported. Each growing season pine infection was restricted to relatively few periods when favorable weather coincided with suitable development of the rust on ribes. The minimum time required for pine infection was 11.5 hours but the amount of infection was greater after 19.5 hours.

Thus extended periods of weather conducive to pine infection will result in more cankers. The optimum temperature for pine infection ranged from 50°F. to 65°F. The important sources of moisture in the experimental area were rain, fog, and dew, rain being the most important. Plantations established where favorable weather for infection is frequent, may need a wider ribes-free border, and more frequent inspection and ribes eradication than in less favorable areas.

128

Hirt, Ray R. 1944. Distribution of blister-rust cankers on eastern white pine according to age of needle-bearing wood at time of infection. Jour. Forestry 42 (1) :9-12.

The majority of the cankers studied developed on wood that was 1 year old at the time of infection. This occurred in potted pines and in natural reproduction of *Pinus strobus*. In study plots the relative amount of infection for any season can be approximated by autumn of the next year from bark cankers, and accurate conclusions can be reached by canker counts the next spring. Such data are useful in relating infection to weather conditions for a specific year.

129

Hirt, Ray R. 1948. Evidence of resistance to blister rust by eastern white pine growing in the Northeast. Jour. Forestry 46 (12) :911-913.

Among trees that were exposed to infection by the blister rust fungus as early as 1927, a few failed to develop infection even though the remaining trees developed from one to many cankers per tree. An occasional infected tree showed slow development of a canker and a few cankers died upon such trees. Some of these trees were moved to a test garden for further study and attempts to reproduce them vegetatively were begun. These trees are thought to show evidence of resistance to *Cronartium ribicola*.

130

Hirt, Ray R. 1950. Know blister rust and save your white pines. N. Y. State Coll. Forestry Circ.

A condensed illustrated story of the factors influencing rust infection of eastern white pine, and suggested control measures. (For popular use.)

131

Hirt, Ray R. 1955. Blister rust resistance in eastern white pine. New York Forester 12 (2) :3-4.

This is a brief summary of the research being done to discover and test eastern white pine trees that give some promise of blister rust resistance. There is good proof that some eastern white pine trees do have a resistance factor. If this can be manipulated successfully by tree breeding techniques, it is possible that offspring of great resistance or even immunity may be produced.

132

Hirt, Ray R. 1956. Fifty years of white pine blister rust in the Northeast. Jour. Forestry 54 (7) :436-438.

This briefly gives the history of the blister rust disease of *Pinus strobus* in the Northeast from its introduction into America up to its status in 1956. A list of eleven selected references of historic interest is included. (These references are not abstracted and included in the present paper.)

133

Honey, E. E. and H. N. Putnam. 1947. Ribes eradication to protect a white pine area previously protected, Deer Lake Plot, Michigan. U. S. Dept. Agric. Bur. Ent. and Plt. Quar. Tech. Memo No. 8.

A careful study of the plot justified the conclusion that, "It is economically sound to protect existing white pine values from blister rust, where no other valuable tree species are present, even on areas whose ribes are abundant, and the rust is well established. Thus control not only assures protection of existing healthy white pines, but also permits restocking through natural means." (The writers are thoroughly experienced in blister rust control.)

134

Humphrey, H. B. 1935. Diseases of plants in the United States in 1933. Plant Disease Reporter Supplement 86:1-107. White pine blister rust.

See Abstract No. 250.

135

Lindgren, R. M. and A. D. Chapman. 1933. Field inoculations of *Pinus strobus* with sporidia of *Cronartium ribicola* in Minnesota. Phytopath. 23 (1) :105-107.

Artificial inoculation of naturally established young eastern white pines was accomplished. Pronounced differences in the amount of pine infection was noted.

136

McCallum, A. W. 1938. Some observations on white pine blister rust in Ontario. Jour. Forestry 36 (10) :997-998.

This is concerned with the status of the rust in Ontario up to 1938. Blister rust control had not been undertaken due to doubt as to the necessity for control, and the expense of ribes eradication. It is concluded that no tree species can be placed under forest management without a charge for protection against fungi, insects, and fire. Thus it seemed advisable to expend monies to protect their most desirable forest tree species, eastern white pine.

137

McGinn, W. K. and A. G. Davidson. 1953. Studies on white pine blister rust in Nova Scotia. For. Chron. 29 (3) :267-272.

The study indicates that, in 10 plots studied, blister rust is not a major factor in retarding the establishment of white pine regeneration. No relation was found to exist between ribes establishment and the degree of cutting in white pine stands.

138

McIntyre, H. L. and H. G. Strait. 1930. History and control of white pine blister rust in New York State. New York State Conserv. Dept. Bull. 18.

The information in the bulletin follows the theme of the title. It is written and illustrated for popular use.

139

McIntyre, H. L. 1942. White pine blister rust control policies in New York State. Jour. Forestry 40 (10) :782-785.

This is a brief review of control policies in New York and their justification. A modification of policy was instituted so that in dense woodland and swamp the border ribes-free strip was reduced to 50 feet wide instead of the usual 900 feet. In open woodland it was reduced to 200 feet.

140

Martin, J. F. 1938. Some economic aspects of white pine blister rust control. Jour. Forestry 36 (10):986-996.

The paper is concerned largely with control of the blister rust disease on native 5-needle white pines, including *Pinus strobus*. Topics covered are: justification of control measures; early efforts to eradicate the pathogen; development, organization and costs of the control program, and results obtained through 1937.

141

Martin, J. F. 1940. The application of surgery to blister rust infected trees of ornamental value. Sixteenth Natl. Shade Tree Conf. Proc. Pp. 113-120.

Branch cankers are eliminated by pruning the infected branches. If the canker margin is 5 inches or less from the stem, the branch should be cut flush with the stem and the stem bark removed for a sufficient distance to allow a full 5 inches between the edge of the original canker and the edge of the wound. For large trunk cankers, the margin should be located and the infected bark of the canker and surrounding healthy bark removed for a distance of 2 inches laterally and 4 inches vertically beyond the canker margin. Treatment is not advised if more than one-half the trunk circumference is involved.

142

Martin, J. F. 1943. Protective zones for blister rust control operations in the eastern white pine region. Div. Plt. Disease Control, Bur. Ent. and Plt. Quar. April 15.

A condensed set of directions for control operations. One mimeographed sheet.

143

Martin, J. F. 1944. Ribes eradication effectively controls white pine blister rust. Jour. Forestry 42 (4) :255-260.

Practical control of white pine blister rust has been underway in the Northeast since 1918. Successful results are now evident. Blister rust is controlled by reducing ribes to an average of 25 feet of live stem per acre. Effective ribes eradication also permits protected areas to restock naturally.

144

Martin, J. F. and G. F. Gravatt. 1942. Treatment of white pines infected with blister rust. U. S. Dept. Agric. Farmers' Bull. No. 1885.

This is an informative bulletin for public information. It covers various phases of the disease on white pines of the forest and those used for ornamental purposes, stressing control practices. Many excellent illustrations are included.

145

Martin, J. F. and G. F. Gravatt. 1954. Saving white pines by removing blister rust cankers. U. S. Dept. Agric. Circ. No. 948.

This publication brings up to date and is a substitute for Farmers' Bulletin No. 1885. Whereas the subject of white pine blister rust is covered in a general way, emphasis is placed on surgical removal of cankered bark of particularly valuable white pines. Illustrations are excellent. (The authors are men of long experience in directing blister rust control in the United States.)

146

Offord, H. R., C. R. Quick, and V. D. Moss. 1958. Blister rust control aided by the use of chemicals for killing ribes. Jour. Forestry 56 (1):12-18.

This is an excellent detailed discussion of ribes control in white pine regions of the United States by use of 2,4-D and 2,4,5-T. Successful control has been accomplished with these chemicals applied as aqueous sprays to the foliage and stems; as oil-extended sprays to basal stems and root-crown; and liquid or dry powder to cut surfaces of plants decapitated at ground level. A table is included that lists the important ribes species associated with white pine types, and gives the most effective and economic phenoxy herbicides for killing each species by foliar spray. These 2 specific herbicides are relatively inexpensive, effective in small bulk or weight, non-inflammable, and non-poisonous to man, fish, and wild life. (The authors are authorities in their field of endeavor.)

147

Pack, C. L. 1933. White pine blister rust. A half-billion dollar menace. Charles Lathrop Pack Forestry Foundation.

This is a popular treatise of the blister rust disease of 5-needled pines in North America, including *Pinus strobus*. The photographs are excellent. "Equipment for control is limited only by lack of man power and funds, and while these are greater, for the moment, than ever before, the battle for the preservation of these species must have continued support."

148

Paul, B. H. 1918. White pine blister rust. N. Y. State Conserv. Comm. Div. Land and Forests. Bull. 15.

This is one of the early well illustrated discussions of the blister rust disease in the Northeast, particularly in New York. The fungus, the disease, and control measures are briefly described. The first New York law regarding white pine blister rust is included.

149

Pennington, L. H., W. H. Snell, H. H. York, and P. Spaulding. 1921. Investigations of *Cronartium ribicola* in 1920. Phytopath. 11 (4):170-172.

The accomplishments of the year are briefly reviewed. Among other results it was indicated that ribes may be killed by heavy foliage infection. The long distance spread of aeciospores from infected pines to distant ribes was verified.

150

Perry, C. C. 1936. Blister-rust control manual for field men. Northeastern states. Northeastern States and U. S. Dept. Agric.

This is just what the title states, a field manual containing valuable information for those employed in blister rust control in the Northeast.

151

Perry, C. C. 1953. Chronological outline summary of developments in white pine blister rust control in the United States, 1906-1952. U. S. Dept. Agric. Bur. Ent. and Plt. Quar. Northeastern Region. Mimeo.

This, as the title states, is an excellent chronological statement of the control measures, accomplishments, and publication titles. References number 260.

152

Pomerleau, René. 1951. White-pine blister rust. Annual Forest Insect and Disease Surv. Canadian Dept. Agric. Div. of For. Biol. Sci. Service. P. 125.

A brief but interesting statement showing that although *Cronartium ribicola* is present throughout the range of white pine in Quebec, little spectacular damage was noticed in natural stands. Plantations did show damage. The cumulative effect of the disease is fairly important.

153

Posey, G. B. and E. R. Ford. 1924. Survey of blister rust infection on pines at Kittery Point, Maine, and the effect of ribes eradication in controlling the disease. Jour. Agric. Res. 28 (12) :1253-1257.

Cultivated *Ribes nigrum* of long standing was the primary source of infection. The greatest amount of pine infection was in the path of prevailing winds of summer and autumn. Ribes eradication was an effective control measure.

154

Putnam, H. N. 1944. Status of blister rust control in northeastern Minnesota. U. S. Dept. Agric. Bur. of Ent. and Plt. Quar. Tech. Memo No. 4.

This report is included because it gives an excellent summary of blister rust control for Minnesota and refers to the situation in Michigan and Wisconsin. By 1944, blister rust was thoroughly established and had reached the damage stage in many stands. A great acceleration in ribes eradication for 20 years would be needed to secure all-over control.

155

Rhoads, A. S. 1920. Studies on the rate of growth and behavior of the blister rust on white pine in 1918. Phytopath. 10 (12) :513-527.

Aeciospore dissemination from eastern white pine lasts for about 4 weeks each spring. From May 1 through mid-September vertical extension of the cankers both up and down averaged 5 inches, horizontally, 2.5 inches. Growth was most rapid during the latter part of the summer. In stems of small diameter, the more rapid growth is downward. Many secondary fungi interfere with the development of blister rust. (This is a broader study than the title indicates.)

156

Richards, J. L. 1927. Susceptibility of different aged pine needles to blister rust and relation between the number of infections on pines and the persistence of their needles. Supplement to Blister Rust News 11 (9) :241-252.

The relative susceptibility of eastern white pine needles to rust infection increases with age of the needles. The shorter the period of needle retention the fewer will be the cankers. The effect of higher susceptibility of older needles is counterbalanced by rapid shedding of needles after their second season. Year-old needles were responsible for producing the highest per cent of blister rust cankers. (Although Richard's results were questioned somewhat at the time, his conclusions have proven to be correct.)

157

Riker, A. J., T. F. Kouba, W. H. Brener, and L. E. Byam. 1943. White pine selections tested for resistance to blister rust. Jour. Forestry 41 (10) :753-760.

Trees of eastern white pine that showed no evidences of blister rust cankers after years of close association with infected ribes were chosen for rust resistance tests. About 1000 grafts and 10,000 open-pollinated seedlings were used. Following severe inoculation a high per cent of seedlings became infected but only a low per cent of the grafts. (This work marks the beginning of resistance tests of white pine in the North Central States.)

158

Riker, A. J. 1945. Some possibilities for developing resistance to disease in trees. Amer. Nurseryman 81 (12) :5-7.

This discusses the mechanism of disease resistance, means of developing disease resistant plants, some representative problems, and vegetative propagation. Approximately 1000 grafts and 10,000 seedlings of eastern white pine were being tested for resistance to the blister rust disease. Preliminary results were encouraging. Test materials were taken from 163 trees selected because of their apparent resistance to *Cronartium ribicola.*

159

Riker, A. J. 1948. Developing resistance to disease in trees. 24th Natl. Shade Tree Conf. Proc. Pp. 65-73.

This is a brief but pointed discussion of causes of disease, control measures, mechanism of disease resistance, and some representative problems, including white pine blister rust. The work being done at Madison, Wisconsin on testing selected, apparently rust-resistance white pines is reviewed.

160

Rusden, P. L. 1952. Blister rust damage at Waterford, Vermont. Jour. Forestry 50 (7) :545-551.

The report represents the longest series of observations on blister rust available for eastern white pine in North America. The rust is not a reliable thinning agent for mature pine as tree loss may be excessive. The rust fungus attacks trees of all height classes. By 1945 in a study area there were 63 crop and 35 non-crop trees killed by the rust per acre, or 73.4 per cent of the crop stems. Without salvage, the apparent volume loss would have been 73.2 per cent. Two essential steps to minimize damage to pine where blister rust is already present are: destroy all ribes in and adjacent to the stand; follow a plan of silvicultural management that includes provision for salvage of infected crop trees before their death from rust makes them a total loss.

161

Snell, W. H. 1929. Some observations upon the white pine blister rust in New York. Phytopath. 19 (3) :269-283.

Pine infection epidemics for 1919, 1925 and 1927 are referred to. Even during years unfavorable for blister rust, momentum is acquired by showers of sporidia on pines when conditions are favorable. Small animals and secondary fungi destroy some inoculum. *Dasyscypha agassizii* is reported on blister rust cankers of *Pinus strobus.* Rodents, slugs and snails feed on pycnia and the two latter on aeciospores.

162

Snell, W. H. 1931. Forest damage and the white pine blister rust. Jour. Forestry 29 (1):68-78.

Eight plots of eastern white pines with blister rust present were studied from the standpoint of actual damage. The conclusion is reached that forest pathology must attack disease problems, blister rust included, from a silvicultural viewpoint in terms of the mature stand of surviving trees. The damage data for 8 study plots are presented with the loss factor in board feet. There is no correlation between percentages of infection and imminent mortality, and percentages of loss in board feet.

163

Snell, W. H. 1931. The Kelm Mountain blister-rust infestation. Phytopath. 21 (9) :919-921.

A stand of young eastern white pines was found in Warren County, New York, which, on the basis of trees, had nearly 100 per cent infection in 1923. On a 2-acre study plot within the stand, about 9000 cankers were present averaging 9 cankers per tree, but ranging as high as 298 cankers on one tree. In 1923, 9 per cent of the trees were dead; in 1930, 69 per cent. In 1926 the plot looked like a thriving pine stand; in 1930 it was no longer a pine stand but, due to the death of the infected trees, it had become a hardwood stand. Some white pines remained free of blister rust and may be resistant.

164

Snell, W. H. 1936. The relation of the age of needles of *Pinus strobus* to infection by *Cronartium ribicola.* Phytopath. 26 (11) :1074-1080.

Although the point is not wholly proven, it seems that the current-season needles of eastern white pine are "to a greater or less degree more susceptible to *C. ribicola* than the second season's needles." The conclusion is reached after 15 years of observation and experimentation. (Dr. Snell is well known for his excellent work with fungi of many kinds. More recent studies indicate year-old needles to be the more susceptible.)

165

Snell, W. H. 1941. The relation of cultivated red currants to the white pine blister rust in New York State. Jour. Forestry 39 (10) :859-867. (Also see Jour. Forestry 39 (6) :537-541. 1941.)

In New England and New York studies indicated that native or planted eastern white pines within 60 to 900 feet of cultivated red currants were extremely lightly infected. The conclusion is reached that probably cultivated red currants are not important in the spread of *Cronartium ribicola* to *Pinus strobus.*

166

Spaulding, P. 1909. European currant rust on the white pine in America. U. S. Dept. Agric. Bur. Plt. Indus. Circ. No. 38.

This is one of the earliest statements warning of the presence in America of blister rust infected transplants of eastern white pine. It briefly refers to the life history of the pathogen, symptoms, damage and control, as known in 1909. (Dr. Spaulding probably has had more experience with white pine blister rust in Europe and America than any forest pathologist living in 1958) .

167

Spaulding, P. 1911. The blister rust of white pine. U. S. Dept. Agric. Bur. Plt. Ind. Bull. No. 206.

This is a comprehensive discussion of the pathogen and the disease so far as known up to 1911. The blister-rust situation in the Northeast, Lake States and Canada is reviewed. Practical suggestions for prevention and control are presented.

168

Spaulding, P. 1922. Investigations of the white-pine blister rust. U. S. Dept. Agric. Bull. No. 957.

This study includes a review of the origin and distribution of *Cronartium ribicola,* its pine and ribes hosts and their relative susceptibility, the life history of the pathogen, and suggested control measures. A very complete list of references is given, numbering 180.

169

Spaulding, P. 1925. A partial explanation of the relative susceptibility of the white pines to white pine blister rust (*Cronartium ribicola,* Fischer). Phytopath. 15 (10) :591-597.

White pines are grouped in respect to their apparent susceptibility to blister rust disease. *Pinus strobus* is classed as susceptible. Leaf persistence and distribution of the stomata are compared between pine species classed as immune, resistant, susceptible, and very susceptible, and suggestions made as to the relation of these ratings to stomata distribution and needle retention. (Since 1925 it has been shown that needle penetration by young hyphae of the pathogen may occur directly through expidermal cells.)

170

Spaulding, P. 1956. Diseases of North American trees planted abroad. U. S. Dept. Agric., Agric. Handbook No. 100. Pp. 11-12.

Cronartium ribicola is known to have been present in North America on *Pinus strobus* since 1898. The pathogen is believed to have traveled from eastern Siberia to Europe and then to North America. The distribution of native American 5-needle pines in Europe is given. (This publication is of great value to forest pathologists as a source of information on present and potential diseases of native American trees.)

171

Stewart, D. M. 1957. Factors affecting local control of white pine blister rust in Minnesota. Jour. Forestry 55 (11) :832-837.

Re-establishment of ribes from seed is a major factor in preventing effective and economical control of blister rust of eastern white pine. On an area burned over 26 years previously, blister rust was effectively controlled by one eradication of ribes. On another area burned over 2 years before planting, control by eradication was ineffective due to continued regeneration of ribes beginning within 1 year after fire. Pruning to eliminate cankers from young planted white pine was highly successful. Canker elimination from natural forest trees was somewhat effective but of questionable value as a forest operation.

172

Struckmeyer, B. E. and A. J. Riker. 1951. Wound-periderm formation in white-pine trees resistant to blister rust. Phytopath. 41 (3) :276-281.

Infected white pine trees resistant to blister rust formed wound periderm back of the invading mycelium. In less resistant trees the fungus penetrated the phloem parenchyma before a cork cambium was activated.

173

Van Arsdel, E. P., A. J. Riker and R. F. Patton. 1953. Microclimatic distribution of white pine blister rust in southwestern Wisconsin. Phytopath. 43 (8) : 487-488.

Blister rust infection of eastern white pine was localized in certain places in southern Wisconsin. Studies of moisture and temperature relations to spore germination, indicated that these localized infection areas had a favorable microclimate for spore germination and incubation.

174

Waterman, A. M. 1955. A stain technique for diagnosing blister rust in cankers on white pine. Forest Science 1 (3) :219-221.

This gives a relatively quick method of preparing and staining fresh bark tissue of white pine for the purpose of determining whether it is infected with *Cronartium ribicola.* The fungus mycelium is characterized for recognition microscopically.

175

York, H. H. and W. H. Snell. 1922. Experiments in the infection of *Pinus strobus* with *Cronatrium ribicola.* Phytopath. 12 (3) :148-150.

It seems that 18½ hours of favorable moisture and temperature are necessary for infection of eastern white pine. Probably 12½ hours are required after the sporidia reach the needles of pine seedlings.

176

York, H. H., W. H. Snell, and A. Rathbun-Gravatt. 1927. The results of inoculating *Pinus strobus* with the sporidia of *Cronartium ribicola.* Jour. Agric. Res. 34 (6) :497-510.

Inoculum from 3 ribes species were used. Infection of eastern white pine occurred at high relative humidities and medium temperatures. Both one- and two-year-old needles were susceptible to infection. Cankers developed on wood which was formed the same season and which was formed the season preceding inoculation. (This is one of the early authentic research projects on this phase of blister rust research. The investigators are well known for careful research and conservative conclusions.)

177

Yost, H. E. and G. H. Hepting. 1947. The development of white pine blister rust in an unprotected area in North Carolina. Plt. Dis. Reporter 31 (1):26.

In 1945 blister rust was reported for the first time in Southwestern Ashe County, N. C. It is 100 miles removed from any known pine infection. The infection area is under study for natural spread of infection.

Wood Decay

Wood decay occurs in all of the aerial woody parts of eastern white pine, the root crown, throughout the trunk, and within the larger branches. Decay of importance to man is that which develops in those portions of the trunk that otherwise would serve some useful purpose.

Wood decay is a chemical process initiated by fungous enzymes whereby defective and aged trees are weakened mechanically and made readily susceptible to overthrow or breakage by natural forces. It is also one of nature's means of reducing dead bulky wood substance to a simpler form, which can be gradually incorporated into

a mineral soil to form a relatively fertile water-holding humus favorable for new tree growth.

Success in the growing of healthy white pines, free of decay, requires constant effort to discover and understand the many natural forces that influence the destruction of wood in the living tree, and from such knowledge by proper silvicultural and management practices provide a long-time favorable environment for the development of rot-free trees.

Living eastern white pines in America are affected by relatively few wood-rot fungi of great destructive capacity. However, those few fungi, when uncontrolled, are capable of making the affected trees completely useless to man. Decay of eastern white pine never, so far as the writer is aware, occurs in America in epidemic form, either in artificially or naturally established stands. To be sure, within a localized area a single species of a woodrot fungus may multiply unduly, and cause a temporary period of severe wood destruction. However, decay in living white pine has never built up rapidly, quickly becoming wide-spread and highly destructive, such as the blister rust disease of white pine. Nevertheless, decay of white pine heartwood is constantly going on, and in the aggregate a vast amount of valuable wood substance is lost to man annually.

Decay in living trees is generally a relatively slow process, and in white pine is no exception. There is evidence that some pockets of decay in the trunk may cease to develop further when the healing of wounds is completed. This needs further study, and should be related to the specific fungi involved.

The greatest amount of cull in eastern white pine due to decay apparently is associated with two fungi, *Fomes pini* (Thore) Lloyd and *Polyporus schweinitzii* Fr. The former is found throughout the trunk, the latter is usually confined to the butt log. Two other wood rot fungi are becoming of increasing importance in natural and artificially produced stands, *Fomes annosus* (Fr.) Cke. and *Stereum sanguinolentum* A. and S. *Fomes annosus* is usually a root rot fungus but in the West has been reported as an important cause of trunk rot in western hemlock. *Stereum sanguinolentum* is a wound fungus and consequently is of concern following the pruning of white pine.

Root and butt rot fungi occasionally invade the lower trunk, therefore some of the following references will have been abstracted in a preceding section.

178

Anonymous. 1921. Forest pathology. Canadian Expt. Farms, Div. Bot. Interim Report. Pp. 12, 13.

See Abstract No. 229. (*Polyporus schweinitzii, Trametes pini, Fomes pinicola.*)

179

Abbott, F. H. 1915. The red rot of conifers. Univ. Vermont and State Agric. Coll., Vt. Agric. Expt. Sta. Bull. 191.

Pure white pine stands showed greater amounts of red rot than any other type. When present, it seemed to be more uniformly distributed than in mixed stands. Macroscopic, microscopic, and cultural characteristics of the fungus *Trametes pini* are discussed, as well as its importance in the forest.

180

Baxter, D. V. 1937. Development and succession of forest fungi and diseases in forest plantations. Univ. Michigan School Forestry and Conserv. Circ. No. 1.

See Abstract No. 46. (*Polyporus schweinitzii.*)

181

Baxter, D. V. 1941. Some resupinate polypores from the region of the Great Lakes. XII. Papers Michigan Acad. Sci. 26 (1940):107-121.

See Abstract No. 47. (*Fomes annosus.*)

182

Boyce, J. S. 1950. Development of tree diseases in the United States. Reprint Proc. 7th Intern. Bot. Congress, Stockholm 1950. Pp. 320-322.

Fomes annosus, well known in the United States for a long time as relatively harmless, is becoming increasingly damaging to conifers including *Pinus strobus,* where trees are outside their natural range or on poor sites, and in stands of unnatural composition.

183

Childs, T. W. 1937. Variability of *Polyporus schweinitzii* in culture. Phytopath. 27 (1) :29-50.

See Abstract No. 48. (*Polyporus schweinitzii.*)

184

Christensen, C. M. 1940. Observations on *Polyporus circinatus.* Phytopath. 30 (11) :957-963.

Brief comments are made particularly about the effects of the fungus on roots of white spruce. Culture characteristics of the fungus are given and the statement is made that cultures of *Fomes pini* from infected white pine in Minnesota can be distinguished from those of *P. circinatus.* (The latter fungus also occurs on roots of white pine.)

185

Clark, J. W. 1957. Comparative decay resistance of some common pines, hemlock, spruce, and true fir. Forest Science 3 (4) :314-320.

Laboratory tests of wood from 13 species of conifers subjected to decay by *Poria monticola, Lenzites saeparia,* and *L. trabea,* indicate that eastern white pine possibly has moderate decay resistance comparable to douglas fir. Samples varied from moderate to "resistant" and "very resistant." This suggests the possibility of using trees with such highly resistant wood in forest tree improvement programs.

186

Faull, J. H. 1916. *Fomes officinalis.* A timber destroying fungus. Forestry Quarterly 14 (4) :737-739.

The "pineapple fungus" *Fomes officinalis* causes the red heart of conifers. It occurs throughout Ontario and Quebec on *Pinus strobus* and has been reported from Michigan on the same host.

187

Faull, J. H. 1922. Butt rots. Rept. Minister Lands and Forest, Prov. Ontario, for Year 1921. Pp. 260-261.

Polyporus tomentosus is recorded for the first time as causing a serious root and butt rot of white pine and certain other conifers in Temagami Forest Reserve of Ontario, Canada. In the Otter District a high percentage of white pine was affected to such an extent that the butt log was of no value. (*Polyporus tomentosus* Fries is synonym for *P. circinatus* Fries.)

188

Fisher, R. T. 1928. Pine plantations and New England forestry. Jour. Forestry 26 (6) :790-793.

Pure pine stands both in natural woodlots and in plantations are silvically alike. At 50 to 60 years, growth falls off rapidly, general health declines, and disease is frequent, especially red rot caused by *Trametes pini.* In mixed rather than pure stands general forest sanitation is most effective, and insects and diseases are less likely to become epidemic. (A provacative article for the forester.)

189

Foster, C. H. 1953. The importance of timber quality as a goal in silviculture. Jour. Forestry 51 (7) :487-490.

Red rot often enters pine through weevil injuries. Partial shading being a major factor in preventing weevil injury, a substantial improvement in future timber quality of white pine will result from the continuous shelterwood system.

Small limbs resulting from crowding are very economically removed in pruning and they heal over rapidly, shortening the period when heart-rot fungi are able to enter the stem. High density contributes to development of tall, straight trees with little taper and with small knots, and hence with less danger of infection by heartrot fungi through dead branches. (*Fomes pini.*)

190

Foster, R. W. 1957. A study of the growth and value of a high-quality eastern white pine tree. Jour. Forestry 55 (10) :727-730.

An intensive study of a 125-year-old select eastern white pine growing in the Adirondacks revealed a height growth of 110 feet; d.b.h. of 30 inches; volume of 1513 board feet; and stumpage value of $133.95. Three-log-pruning at proper time would have increased value to $233.86 by increased lumber value and reduction of loss in value due to red rot caused by *Fomes pini.*

191

Graves, A. H. 1913. Notes on diseases of trees in the southern Appalachians 1. Phytopath. 3 (2) :129-139.

See Abstract No. 245. (*Fomes pini.*)

192

Haddow, W. R. 1933. Disease as a factor in the transition of pine to stable types. Forestry Chronicle 9 (1) :30-35.

See Abstract No. 52. (*Armillaria mellea, Polyporus schweinitzii, Trametes pini, Fomes laricis, F. pinicola, F. roseus.*)

Haddow, W. R. 1934. An instance of early infection of white pine (*Pinus strobus* L.), by *Trametes pini*. Forestry Chron. 10 (4):199-202; Forestry 8 (2): 155-157.

Decay of white pine by *Trametes pini* in eastern Canada is the most destructive wood rot. Damage accrues largely in timber of merchantable size, but young stands are also attacked. Primary infection of trees seems to take place through dead branches. The fungus is able to destroy even resin impregnated wood. In a planting of white pine a tree decayed by *T. pini* was determined to have become infected through a branch stub at an age between 16 and 19 years.

194

Haddow, W. R. 1938. The disease caused by *Trametes pini* (Thore.) Fries in white pine (*Pinus strobus* L.). Trans. Royal Canadian Instit. No. 47, 22 (1): 21-81.

This is a detailed study of the fungus *Trametes pini* in eastern white pine. In Ontario and probably throughout the range of the pine host the fungus is thought to be the most destructive of the wood rotting fungi of white pine. While typically a heartrot fungus, it also is parasitic in pine. The fungus normally fruits on dead pine of large size. Cull logs from infected trees and windthrown timber produce much inoculum which infects reproduction. Most infection occurs through branch stubs. Killed leaders including that destroyed by pine weevil may serve as courts of establishment by the fungus. Control of the fungus in pine stands is discussed. (This paper and that of Foster's, Abstract No. 189, suggest a relationship between pine weevil injury and infection by the red rot fungus, *Fomes pini*.)

195

Hansbrough, J. R. 1948. Forest disease problems in the Northeast. New York Forester 5 (2):6-9.

Root and butt rot of pole-size white pine, artificially and naturally reproduced, are widely reported in the Northeast. *Polyporus schweinitzii* and *Fomes annosus* are usually implicated. It appears that the former fungus is associated when soils of high pH are involved and the latter fungus when light sandy soils make up the substratum.

196

Hedgcock, G. G. 1914. Notes on some diseases of trees in our national forests. IV. Phytopath. 4:181-188.

Fomes pinicola occurs on many pines including eastern white pine, where it causes yellow to yellow-brown cubical rot. It attacks the sapwood primarily. Its usual entrance is through wounds. *Fomes roseus* is reported as a cause of brown brittle rot in white pine as well as other hosts.

197

Hepting, G. H. 1941. Eastern forest tree diseases in relation to stand improvement. Fed. Security Agency Civilian Conserv. Corps, Forestry Publ. No. 2. P. 12.

Trametes pini causes the most important disease of conifers in the United States, and is especially important on *Pinus strobus* in the Northeast and Lake States. Infection occurs mostly through dead branch stubs. Resin exudation at branch scars, punk knots, and occasional fruit bodies are evidences of infection in living trees. (The publication is an excellent condensation of information regarding important diseases of eastern forest trees by an experienced forest pathologist.)

198

Hepting, G. H. and A. A. Downs. 1944. Root and butt rot in planted white pine at Biltmore, North Carolina. Jour. Forestry 42 (3) :119-123.

See Abstract No. 57. (*Fomes annosus, Polyporus schweinitzii.*)

199

Hepting, G. H., Elmer R. Roth and Bailey Sleeth. 1949. Discolorations and decay from increment borings. Jour. Forestry 47 (5) :366-370.

Increment borings in white pine healed with no external effect and without subsequent internal decay. Localized pitch-soak involving about 3 liner inches developed.

200

Hilborn, M. T. and F. L. Markin. 1938. List of causes of fungus and bacterial plant diseases in Maine to 1936 inclusive. Plant Disease Reporter Supplement 105:1-60.

See Abstract No. 89. (*Fomes pini, F. pinicola, Polyporus schweinitzii, Thelephora laciniata.*)

201

Huberman, M. A. 1943. Sunscald of eastern white pine, *Pinus strobus* L. Ecol. 24 (4) :456-471.

This is a thorough discussion of the development of sunscald of white pine and the predisposing causes. Among the several effects of sunscald is the establishment of insect and fungus pests in the open wounds.

202

Hubert, E. E. 1929. A root and butt rot of conifers caused by *Polyporus circinatus* Fr. Phytopath. 19 (8) :745-747.

The rots caused by *P. circinatus* and *Fomes pini* are contrasted, as well as the sporophores of *P. circinatus* and *P. schweinitzii.* Infection of eastern white pine is referred to. Although the paper is concerned in a large measure with western conifers, it is of interest to eastern foresters.

203

Humphrey, H. B. 1935. Diseases of plants in the United States in 1933. Plant Disease Reporter Supplement 86:1-107.

See Abstract No. 250. (*Fomes pini, Armillaria mellea, Polyporus schweinitzii.*)

204

Kauffman, C. H. 1917. Unreported Michigan fungi for 1915 and 1916, with an index to the hosts and substrata of basidiomycetes. 19th Michigan Acad. Sci. Report. Pp. 145-157.

Numerous fungi are listed as having been collected from eastern white pine as a substratum, including 19 hymenomycetes. (It is not always possible for the reader to determine whether the fungi occurred on living white pine or simply on dead wood.)

205

Lorenz, R. C. and C. H. Christensen. 1937. A survey of forest tree diseases and their relation to tree improvement in the Lake and Central States. U. S. Dept. Agric. Forest Serv., Reg. 9, Univ. Minnesota. Processed.

See Abstract No. 59. (*Armillaria mellea, Fomes pini.*)

206

Lowe, J. L. 1934. The Polyporaceae of New York State. Pileate species. New York State Coll. Forestry Tech. Bull. 41.

This is a descriptive key to the Polyporaceae of New York State by a world authority of these particular fungi. Following the description of each fungus there is a list of substrata including living host species, among which the various pines are frequently mentioned. The publication is of great value to the forest pathologist as well as mycologist.

207

Mounce, Irene. 1929. Studies in forest pathology. 2. Biology of *Fomes pinicola* (SW.) Cooke. Canadian Dept. Agric. Bull. No. 111. New series.

This is an excellent biology of the fungus *Fomes pinicola,* in which *Pinus strobus* is listed as a host. The fungus was also cultured on wood of white pine and developed the typical brown cubical rot. Isolates of the fungus from infected pines were used in studies of bisexual strains of the fungus.

208

Nobles, M. K. 1953. Studies in wood-inhabiting hymenomycetes. 1. *Odontia bicolor.* Canadian Jour. Botany, 31:745-749.

This fungus is associated with butt rot in various species of trees including *Pinus strobus.* Establishment apparently occurs in the roots and the fungus grows upward into the basal part of the trunk. Only heartwood is invaded. A white stringy rot with black flecks results. (Excellent photographs accompany the description of the fungus.)

209

Ostrander, M. D. and C. H. Foster. 1957. Weevil-red rot associations in eastern white pine. Northeastern Forest Expt. Sta. Forest Research Notes. No. 68.

A white pine log-grade study at Warrensburg, New York, indicates weevil injuries to be sources of establishment for the red rot fungus, *Fomes pini.* Until a practical means of weevil control is perfected, losses due to red rot can be minimized by removal of weeviled trees during thinning operations and the removal of weeviled leaders while pruning.

210

Owens, C. E. 1936. Studies on the wood-rotting fungus *Fomes pini.* I. Variations in morphology and growth habit. II. Culture characteristics. Amer. Jour. Bot. 23 (2):144-158, (4):235-254.

Sporophores of the fungus *Fomes pini* were collected, chiefly from the Pacific Northwest and studied for structural characteristics. Considerable variation is reported between those collected from different tree genera and species as well as collections from a single host. From culture studies on agar, the cultures were differentiated into 3 groups: A — rapid growth with fluffy thick mycelial mat and colors of buff shades; B — slower growth, thin less fluffy mat and darker colored; C — growth speed similar to Group A, felty compact mycelial mat with distinct brown color. Isolate from *Pinus strobus* fell in group A.

211

Pennington, L. H. 1907. *Fomes pinicola* Fr. and its hosts. 9th Report Michigan Acad. Sci. Pp. 80-82.

Eastern white pine was reported as one of numerous hosts of the fungus in northern Michigan. Fruit bodies of the fungus occurred more generally on dead trunks that showed advanced decay.

212

Percival, W. C. 1933. A contribution to the biology of *Fomes pini* (Thore.) Lloyd (*Tramates pini* [Thore.] Fries). New York State Coll. Forestry Tech. Bull. No. 40.

This is an excellent study of *F. pini* that contributed new information to certain phases of its biology. A conclusion is reached that, by spores, the fungus may pass from infected spruce trees to healthy white pine. Because infected spruce logs left on the ground produce fruit bodies of the fungus in considerable abundance, spruce slash left after logging operations can be a serious source of inoculum for nearby white pine stands. Fruit bodies are produced in much less abundance on pine logs and hence pine slash is less hazardous as a source of inoculum.

213

Proctor, Phimister. 1941. Penetration of the walls of wood cells by the hyphae of wood-destroying fungi. Yale Univ. School For. Bull. No. 47.

The study of hyphal penetration of wood cells included eastern white pine wood and 3 fungi that cause decay in living white pines: *Fomes annosus, F. pini,* and *Polyporus schweinitzii.* It was concluded that penetration of walls of wood cells is accomplished following chemical disintegration of the wall substance by enzymes secreted by the hyphal tips. Actual passage of a hypha through the cell walls is through the preformed opening and without actual contact between the hyphae and the penetrated cell wall. (It is reasonable to assume that the method of cell wall penetration in wood, whether intact in the living tree or removed from it, will be the same.)

214

Sleeth, Bailey. 1938. Pruning wounds as an avenue of entrance for *Stereum sanguinolentum* in northern white pine plantations. U. S. Dept. Agric. Allegheny Forest Expt. Sta. Tech. Note No. 22.

In Pennsylvania the fungus was found fruiting on pruning wounds 2 to 5 years old. Sporophores are described. From 4- to 5-year-old wounds decay extended a maximum of 24 inches. No visible decay was observed associated with 2-year-old wounds. *S. sanguinolentum* must be considered an important wood-rot fungus in pruned white pine. Young trees infected with the fungus should be marked for early removal.

215

Snell, W. H. 1931. Tree diseases in New York. Plant Disease Reporter 15 (10):112.

Lentinus lepideus was associated with heartrot in a few eastern white pine trees injured by lightening or breakage.

216

Spaulding, Perley. 1929. Decay of slash of northern white pine in southern New England. U. S. Dept. Agric. Tech. Bull. No. 132.

Whereas this is a study of slash decomposition in the forest, reference to the living tree is made in the significant statement that, "None of the fungi found rotting white pine slash, with the possible exception of *Stereum sanguinolentum,* appears to be threatening to the new forest following the one producing the slash." (Since this bulletin appeared, the fungus has been found attacking pruning wounds of white pine.)

Spaulding, Perley. 1937. Red ring rot of conifers. Massachusetts Forest and Park Assoc. Tree Pest Leaflet No. 17.

This is a condensed semi-technical discussion of rot by *Fomes pini* on its several hosts, including eastern white pine. Disease symptoms, the fungus, its life history, spread and control are covered.

218

Spaulding, Perley, H. J. Baldwin and J. S. Boyce. 1935. Forest disease control in New England. Jour. Forestry 33 (5):469-473.

Stereum sanguinolentum has been found in pruning wounds of white pine in experimental pruning of large living branches, where pitch flow did not cover the wounds. Within 2 years decay was present in the wounds and adjacent trunk, and the fungus had formed fruit bodies. The fungous agent may be a serious factor when living branches are pruned.

219

Spaulding, Perley and J. R. Hansbrough. 1944. Decay of logging slash in the Northeast. U. S. Dept. Agric. Bur. Plt. Ind., Soils, and Agric. Engin. Tech. Bull. No. 876.

A list is given of 26 of the more important fungi found on white pine slash. For logging slash it is stated that a number of slash fungi may be potentially dangerous, but most of them are so common on large logs, broken and wind-thrown trees that their spores are present normally in abundance in the forest, even where little or no cutting has been done. Eastern white pine injured during logging operations appears to be especially susceptible to damage by trunk rot and to decay entering through broken living branches of the lower crown. Even so, if reasonable care is taken to avoid such injuries, slash fungi do not materially increase the usual decay hazard.

220

Spaulding, P., H. J. MacAloney, and A. C. Cline. 1935. *Stereum sanguinolentum*, a dangerous fungus in pruning wounds on northern white pine. U.S. Dept. Agric. Northeastern Forest Expt. Sta. Tech. Note. No. 19. Mimeographed.

The fungus is known to cause decay of Norway spruce and Scotch pine in Europe, balsam fir in Canada, Maine, New Hampshire and New York. Following pruning experiments of eastern white pine in the United States, rot by the fungus was found in pruning wounds of branches 3 to 5 inches in diameter. Pruning of branches so large that the heartwood is not covered with pitch is a dangerous practice. If the fungus becomes established in young pruned trees, they will become worthless before they reach merchantable size. (The three writers are responsible foresters with long experience.)

221

Stevenson, J. A. and R. J. Haskell. 1929. *Lentinus lepideus* Fr. on *Pinus strobus*. Plant Disease Reporter 13 (2):28.

The fungus was reported on eastern white pine from Washington, D.C.

222

Stillwell, M. A. and A. G. Davidson. 1953. Maritime Provinces. Canadian Dept. Agric. Ann. Report, Forest Insect and Disease Survey, Science Service. Pp. 20-31.

Polyporus cinnabarinus Jacq. ex Fr., listed in a table of noteworthy tree diseases in Canada, is recorded on living eastern white pine in Nova Scotia

as a cause of white rot. (This fungus is considered to be a saprophyte and not a cause of disease in living trees. Since other saprophytic fungi also are included in the table, the pathogenicity of *P. cinnabarinus* may be doubtful.)

223

Von Schrenk, H. 1900. Some diseases of New England conifers. U.S. Dept. Agric. Div. Veg. Physiol. and Pathology Bull. No. 25.

The following fungi and the wood decays associated with them in living white pines are discussed in considerable detail. *Polyporus schweinitzii, P. (Fomes) pinicola, Trametes (Fomes) pini, Poria subacida.* (Photographic illustrations of the rots and the fungi are excellent. The paper is of interest particularly because of its historic value.)

224

Wagener, W. W. and Ross W. Davidson. 1954. Heartrots in living trees. Bot. Rev. 20 (2):61-134.

This is an excellent summary of heartrot in living trees, by two forest pathologists of extensive experience. Heartrot of eastern white pine is referred to frequently and discussed. Three hundred forty-five literature citations are listed.

225

Wean, R. E. 1937. The parasitism of *Polyporus schweinitzii* on seedling *Pinus strobus.* Phytopath. 27 (12):1124-1142.

See Abstract No. 23 *(Polyporus schweinitzii.)*

226

White, L. T. 1953. Studies in forest pathology. X. Decay of white pine in the Timagami Lake and Ottawa Valley areas. Canadian Jour. Bot. 31:175-200.

White pines in the number of 1012 trees were examined. A relationship between age and decay was found. The proportion of trees with decay increased gradually from 40 per cent in the 60-year age class to 100 per cent in the 220-year age class. Merchantable volume loss increased from 4 per cent at 60 years to 40 per cent at 200 years. Pathological rotation was indicated as 160 to 170 years. Thirteen wood decay fungi are listed. *Fomes pini* was responsible for 90 per cent of all loss in trunks and butts of trees. In white pine, trunk rots are responsible for more than 85 per cent of the total loss through decay. *Corticium galactinum* was found to cause over 10 per cent of all butt rot infections, but only recently has come to be regarded as an important pathogen of forest trees. (This is an excellent study of decay of white pine within a localized forest area of eastern Canada.)

227

York, H. H. 1938. Some diseases in forest plantings of white pine and red pine in western New York. Phytopath. 28 (1):22.

See Abstract No. 66. *(Polyporus schweinitzii.)*

228

Zabel, R. A. 1956. Decay resistance variations within northeastern forest tree species. Third Northeastern Forest Tree Improvement Conference Proceedings. Pp. 13-17

Wood durability is the natural resistance of wood to decay activities of wood-destroying fungi. Aged sound trees occasionally occur in the forest which suggests that our forests may contain some trees with unusual resistance to heartrot. A cooperative study of durability of selected eastern white pine trees is in progress at the State University College of Forestry, Syracuse, New York.

FOLIAGE DISEASES

There are relatively few fungous diseases of eastern white pine foliage in North America and none that have proven extremely serious. The blister rust disease of white pine begins as a needle infection, to be sure, but the main activity of the fungus is confined to the bark.

There is some question as to the cause of the needle blight disease of eastern white pine. Early literature suggests that fungi may be directly or indirectly concerned with the initiation of the disease. A few pathologists have indicated that the trouble may be the result of a virus invasion. The more recent studies, however, present evidence that pathogenic fungi probably are not involved. Because of the controversial nature of the disease, it was decided to include needle blight among the fungous foliage diseases of white pine.

229

Anonymous. 1921. Forest pathology. Canadian Expt. Farms, Div. Bot. Interim Report. Pp. 12, 13 (also Expt. Sta. Records 49:51. 1923).

A study in 1919 of white pine in northern Ontario indicated that needle blight was associated with dead rootlets and absence of mycorrhiza. Prevalent heartrots were caused by *Polyporus schweinitzii, Trametes pini* and *Fomes pinicola.*

230

Anonymous. 1930. Needle blight of white pine. Annual Report to the Legislature, State of New York Conserv., Dept. 20 the Annual Report for the year 1930. Legislative Doc. 38:200-202. (1931).

Needle blight is characterized by browning and necrosis of the outer portions of current-season needles. In the majority of cases it appears to be a physiological disturbance indirectly due to a pathological condition of the tree roots which results in a reduction of the finer roots. Continuously blighted trees may die; those only periodically blighted appear not to be permanently injured. Repeated observations of blighted trees in natural and planted stands show the mycorrhizal rootlets to be heavily infected with fungi or apparently destroyed by a fungus parasite.

231

Anonymous. 1954. A foliage disease of white pine seedlings. Forestry Abstracts 15:305 (Abstract No. 2456); Report Delaware State Forestry Dept. 1952-1953, 1953.

The fungus *Cylindrocladium scoparium* has damaged the foilage of seedling *Pinus strobus* in the nursery. Control was accomplished with each of Manzate, Fermate, and Bordeaux mixture.

232

Anonymous. 1955. White pine needle blight. Forestry Abstracts 16:93 (Abstract No. 737); Report Forest Insect and Disease Survey, Canada 1953, 1954.

Evidence is available indicating that repeated attacks of needle blight may cause the death of *Pinus strobus.* The disease may cause reduced annual increment. It is classed as a physiogenic disease with causal factors unknown.

Boyce, J. S. 1940. Needle cast disease of pine. Massachusetts Forest and Park Assoc. Tree Pest Leaflet No. 44.

A brief semi-technical discussion of needle cast of pines including *Pinus strobus*. Symptoms are given as well as a typical life history. Control in nurseries is suggested. The fungi listed are *Lophodermium pinastri, L. nitens, Hypodermella ampla, Hypoderma lethale, H. desmazierii* and *Bifusella linearis*. Three of these occur on eastern white pine.

234

Boyce, J. S. (Jr.) 1951. *Lophodermium pinastri* and needle browning of southern pines. Jour. Forestry 49 (1):20-24.

The fungus has been collected at the Duke forest from foliage of longleaf, slash, loblolly, shortleaf, red and eastern white pine. The fungus was isolated from a variety of discolored areas of loblolly, shortleaf, and white pine foliage. Unsuccessful efforts to infect needles of southern pine species with inoculum, led to the conclusion that *L. pinastri* (Schrad.) Chev. is probably not pathogenic, but invaded needles weakened by other causes.

235

Campana, R. J. 1953. *Corticium galactinum* and white pine needle blight. Phytopath. 43 (9):468.

Tests in the green house under controlled conditions indicate that the fungus *C. galactinum* is not the cause of needle blight of eastern white pine.

236

Clinton, G. P. and F. A. McCormick. 1919. Infection experiments of *Pinus strobus* with *Cronartium ribicola*. Connecticut Agric. Expt. Sta. Bull. 214:428-459.

This is a very detailed study, excellently illustrated, of the infection of white pine needles by the blister rust fungus. Infection follows inoculation of the needles by wind-blown sporidia. The conclusion is reached that penetration is by way of the stomata since substomatal vescicles occur in substomatal chambers of infected needles. Actual penetration of a needle was not observed. Following penetration of the epidermal tissue, the hyphal mass increases in size, finally invading the phloem of the vascular bundle, and then grows downward to the bark tissues at the base of the infected needle.

237

Clinton, G. P. 1934. Needle cast. Plant Pest Handbook for Connecticut. 2. Diseases and Injuries. Connecticut Agric. Expt. Sta. Bull. 358:294.

Lophodermium lineare was collected on needles of white pine and seemed to be the cause of their death.

238

Dana, S. T. 1908. Extent and importance of the white pine needle blight. U.S. Dept. Agric. Forest Service.

This is one of the earliest references to white pine needle blight in the Northeast. Symptoms are described and the distribution is listed for 1908. The cause is unknown.

239

Dearness, J. 1928. New and noteworthy fungi. V. Mycologia 20 (4):235-246.

Hendersonula pinicola sp. nov. is described. It was found on partly green needles of eastern white pine in North Carolina and in Tennessee. Perhaps

associated with needle cast but parasitism was not proven. *Leptothyrium stenosporum* sp. nov. is described and reported from blighted needles of young white pines.

240

Doolittle, W. T. 1948. White pine blight in relation to site and thinning. Jour. Forestry 46 (12) :928-929.

In 1944 blight was first noted on *Pinus strobus* in the Biltmore plantations. Studies showed that a sharp relation exists between dryness of site and occurrence of blight. On comparable sites there is more blight in thinned than in unthinned stands.

241

Faull, J. H. 1922. Records for 4 years on the needle blight of *Pinus strobus*. Phytopath. 12 (2):58.

Needle blight has been reported since 1905. The cause has been ascribed to winter injury, late frost, insects, fungi and other factors. The trouble begins in the tree roots due in part to drought. Young stands usually recover but mature stands are seriously injured.

242

Faull, J. H. 1922. Needle blight of white pine. Rept. Minister Lands and Forest, Prov. Ontario, for year 1921. Pp. 259-260.

Studies of white pine needle blight, while not complete, indicate that young stands may be seriously depleted, and heavily blighted mature stands may be so badly injured as to be a deciding factor in determining the time of harvest.

243

Faull, J. H. 1922. Some problems of forest pathology in Ontario. Needle blight of white pine. Jour. Forestry 20 (1):67-70.

Needle blight is not due to winter killing, enzymatic disease, fungi or insects. The cause is in the death of the absorbing roots. However, the cause of the death of the roots was not discovered. Young stands are not as seriously affected as mature stands. (This is approximately the extent of our knowledge about this disease in the Northeast in 1958).

244

Fink, B. 1911. Injury to *Pinus strobus* caused by *Cenangium abietis*. Phytopath. 1 (6) :180-183; Ohio Forester 2:5. 1911.

In 1909 six eastern white pine trees in Ohio gave evidence of dead and dying needles. Later fruit bodies of *Cenangium abietis* (Pers.) Dub. appeared on the twigs. The disease was thought to be a factor in the subsequent death of several infected trees. It occurs only occasionally, apparently after seasons of prolonged drought. (*C. abietis* synonym *C. ferruginosum* Fr.)

245

Graves, A. H. 1913. Notes on diseases of trees in the southern Appalachians. I. Phytopath. 3 (2):129-139.

A needle blight of eastern white pine, thought to be caused by *Lophodermium brachysporum Rostrup.*, is described. The disease was reported from North Carolina and Connecticut. In Europe the fungus is a dangerous parasite. *Trametes pini* is reported as the cause of rot in a wind-thrown white pine. A minor bark disease is thought to have been caused by *Coccomyces pini* (Alb. and Schw.) Karst. (These are reports of the presence of fungi on white pine but their parasitic activity is not proven.)

246

Güssow, H. T. 1930. Needle blight of white pine. Canadian Dept. Agric. Div. Botany, Report of Dominion Botanist for 1928. Pp. 31-33.

The wide spread presence of the disease in 1928 in Ontario, Canada followed a period of excess moisture, believed to have drowned the fine rootlets of white pine. (This is a report of the presence of the disease rather than a detailed study of its cause.)

247

Hedgcock, G. G. 1932. Notes on the distribution of some fungi associated with diseases of conifers. Plant Disease Reporter 16 (4):28-42.

The fungi listed on eastern white pine include: *Hypoderma (Bifusella) lineare (Peck)* Thuem. associated with tar-stripe needle blight; *Lophodermium pinastri* (Schrad.) Chev. associated with needle cast; *Asterina pinastri* Sacc. and Ell., *Pestalozzia funerea* Desm., *P. peregrina* E. & M., *Pezizella minuta* Dearn., *Phacidium planum* Davis, *Sclerophoma pini* (Desm.) v. Hoehn, *Septoria spadicea* Patt. and Charles associated with needle blight; *Mollissia pinastri* (C. & P.) Sacc. probably a saprophyte on dead needles.

248

Hilborn, M. T. 1942. 1939, 1940, and 1941 additions to the list of causes of fungus and bacterial plant diseases in Maine. Plt. Dis. Reporter 26 (16):347-349.

Pinus strobus is listed as a host for *Lophodermium pinastri* (Schrad.) Chev.

249

Hirt, Ray R. 1938. Relation of stomata to infection of *Pinus strobus* by *Cronartium ribicola.* Phytopath. 28 (3):180-190.

This is primarily a study of stomatal opening and closing in needles of eastern white pine and needle infection. Some stomata were open at all times but the greatest number between 10 a.m. and 2 p.m. No germ tubes of sporidia were discovered entering pine needles by way of the stomata, but direct penetration of the epidermal tissue was observed.

250

Humphrey, H. B. 1935. Diseases of plants in the United States in 1933. Plant Disease Reporter Supplement 86:107.

Sooty mold by *Capnodium pini* was found on *Pinus strobus* in Connecticut. Other diseases of eastern white pine and pathogens listed are: needle blight; decay by *Fomes (Trametes) pini,* Connecticut; *Armillaria mellea* and *Polyporus schweinitzii,* Minnesota; canker by *Dasyscypha fuscosanguinea,* Michigan; and a detailed report of white pine blister rust in the United States by *Cronartium ribicola.*

251

Ibberson, J. E. and H. Streater. 1952. White pine blight responds to fertilizer applications. Pennsylvania Forests and Waters 4 (2):30-31, 46.

The cause of the blight of eastern white pine is unknown but is believed to be caused by insects or pathogenic fungi that attack the roots. Experimental work indicates that trees showing symptoms of the blight may be saved by applying fertilizer (10-6-4) at the rate of 2 pounds per inch d.b.h.

252

McKenzie, M. A. 1955. Needle blight, mystery disease of eastern white pine. Research in Review, Univ. Massachusetts 4 (1):4-5.

Development of needle blight is imperfectly understood even though after 50 years outbreaks occur frequently on eastern white pine. Affected trees may recover slowly and completely in a year or more without treatment. Hasty action in removing affected trees is not advised since there is no evidence that the disease is contagious.

253

Marshall, R. P. 1948. A white root rot which merits study as a possible cause of white pine blight. Scientific Tree Topics 1 (9):66-68.

See Abstract No. 60. *(Corticium galactinum.)*

254

Marshall, R. P. and A. M. Waterman. 1948. Common diseases of important shade trees. U.S. Dept. Agric. Farmers' Bull. No. 1987:40.

Many pines, including white pine, are susceptible to needle cast caused by species of Hypodermella and Lophodermium. Affected needles fall prematurely but defoliation is usually slight. Control measures are unnecessary since no serious injury usually results except in young nursery trees.

255

Pierson, H. B. 1955. White pine needle blight. Maine, 30th Biennial Report Forest Commissioner, 1953-1954. P. 132.

Eastern white pine with needle blight was wide spread in Maine in 1954. Trees most affected were on dry sites and had many roots killed, apparently by drought. A chemical study of diseased needles showed a deficiency of potassium and magnesium.

256

Pirone, P. P. 1948. Maintenance of shade and ornamental trees. Oxford Univ. Press. N.Y. Pp. 364-366.

Among the pines used for ornamental purposes, white pine appears the least susceptible to tip blight by *Sphaeropsis ellisii* Sacc. The disease is characterized by stunting of the new growth followed by chlorosis and browning of the needles, upon which minute black fruit bodies of the fungus appear. Control consists of pruning twigs to sound wood and then applying a copper spray when new growth appears; next when new growth is lengthened half way, and then again within 10 days to 2 weeks.

257

Siggers, Paul V. 1944. The brown spot needle blight of pine seedlings. U.S. Dept. Agric. Tech. Bull. 870.

The fungus, *Scirrhia acicola,* causes the brown spot needle blight of numerous pines, mostly hard pines, but has been reported from *Pinus strobus* in North Carolina. The bulletin discusses the taxonomy of the fungus, the influences of various environmental factors, the effects of the fungus on its hosts, and control, chiefly in relation to southern hard pines.

258

Spaulding, Perley. 1909. The present status of the white pine blights. U.S. Dept. Agric. Bur. Plt. Indus. Circ. No. 35.

The cause of leaf blight of white pine is unknown but the fungus *Septoria spadicea* Patterson and Charles is commonly associated with the necrotic tips of affected needles. Although trees may die from the blight, the number killed is relatively small. Twig blight caused by *Lophodermium brachysporum* Rostr. was present in Maine on trees 1 to 10 feet high. Some damage

occurred and a considerable number of young trees were killed. The disease was present also on lower branches of older trees. (This is one of the early authentic references to white pine blight in the Northeast.)

259

Spaulding, P. 1909. The white pine blight. Science 29 (753):911.

"This popular term includes several well-marked and distinct diseases: a leaf blight accompanied by *Septoria parasitica,* two leaf diseases caused by *Lophodermium brachysporum* and *Hypoderma lineare,* a leaf and twig blight caused by winter freezing and a twig blight probably caused by insects." (This note is of historic value, largely.)

260

Spaulding, P. and J. R. Hansbrough. 1943. The needle blight of eastern white pine. U.S. Dept. Agric. Agric. Res. Adm. Bur. Plt. Indus. Div. For. Pathol. Mimeo.

The young immature needles develop symptoms after prolonged periods of moist weather followed abruptly by dry, hot days. It is associated with a scarcity of feeding rootlets but no parasitic fungus appears to be involved. Relatively few of the affected trees die. Valuable ornamentals may be fertilized, artifically watered, and mulched as preventative and corrective measures.

261

Stambaugh, W. J. 1952. A study of needle cast diseases of conifers in Pennsylvania. Jour. Forestry 50 (12):944.

Bifusella linearis and *Hypoderma desmazierii* are mildly parasitic on eastern white pine. *Lophodermium pinastri,* while wide spread, is considered to be saprophytic. Needle cast epidemics are closely allied with climatic periods of high humidity and poor vigor of the hosts. In white pine Christmas tree plantations greater defoliation and reduction in grade seems to result from needle blight than from needle cast. Maximum blight intensity affected trees growing in exposed openings.

262

Swingle, R. U. 1944. Chlorotic dwarf of eastern white pine. Plant Dis. Rept. 28 (26):824-825. Also Biol. Abs. Vol. 19, Abstract No. 3707. 1945.

Chlorotic dwarf has been observed since 1936 in Ohio plantings of white pine. It is thought to be the most important disease of young pines 2 to 15 years after planting out. The disease is characterized by chlorotic foliage, stunted roots and needles, and premature casting of year-old needles. Tip burn is common. Affected trees usually die after 2 to 3 years of decline. The agency responsible is unknown. No fungus is consistently isolated from affected trees. Tests for virus are under way. The condition occurs in young plantings in the Lake States, New York and in the Northeast. (This probably is not the same as "needle blight" of white pine although probably confused with it by many observers.)

263

Toole, E. R. 1949. White pine blight in the Southeast. Jour. Forestry 47 (5):378-382. (Also Biol. Abs. 24:228. 1950.)

Symptoms are similar to those described for white pine blight in the Northeast, and in part to chlorotic dwarf described by Swingle. The following fungi were associated with the browned needles: *Hendersonia foliicola, Pestalotia funerea, Lophodermopsis* sp., and *Septoria spadicea.* The latter

was the most common. Root deterioration appears to follow top symptoms. The disease seems to be systematic. Fungi isolated from the needles did not produce the disease after inoculation of healthy needles. White pine blight possibly may be caused by a virus. If so, root aphids may be the transmitting agents. Further study is needed to determine the significance of root fungi and root aphids as the cause or vectors, respectively.

264

Vermillion, M. T. 1950. A needle blight of pine. Lloydia 13 (3):196-197.

A needle blight of eastern white pine seedlings from Ohio was associated with a species of *Pestalozzia* probably *funerea*. Inoculation of healthy seedlings with this fungus produced the typical symptoms of the disease, namely, chlorotic areas at the tips which later turned brown, the discoloration traveling to the base of the needles, followed by needle cast. Seedlings were not killed.

265

Wahlenberg, W. G. 1955. Six thinnings in a 56-year-old pure white pine plantation at Biltmore. Jour. Forestry 53 (5):331-339.

Leaf or needle blight was of minor trouble on a thinned plot. It seemed to be linked with a dryer forest floor in open spots, and may reduce growth by about one-third. Spraying tests appear to have eliminated the likelihood of needle fungi as a cause of the trouble.

266

Walker, E. A. 1947. Eastern white pine affected with needle blight in Maryland. Biol. Abst. 21:994.

The disease is considered physiogenic. Necrosis of the needles is thought to be associated with drying of feeder roots due to hot dry weather. Application of fertilizer, irrigation, and mulching is recommended to stimulate new feeder roots.

267

Waterman, A. M. 1939. The disease of pines caused by *Sphaeropsis ellisii*. Plt. Dis. Reporter. 23 (6):93-95.

Eastern white pine is listed from New York as one of several coniferous hosts attacked by *S. ellisii* Sacc. Infection on white pine is not considered to be serious. On ornamentals the fungus is controlled by 3 to 4 properly timed applications of 4-4-50 Bordeaux.

268

Waterman, A. M. 1943. *Diplodia pinea*, the cause of a disease of hard pines. Phytopath. 33 (11):1018-1031.

D. pinea was indicated for the first time in 1917 as a parasite in the United States, causing dying of needles of hard pine in New Jersey. In 1932 it was reported as a weak parasite on 11 species of hard and soft pines including *Pinus strobus* in eastern and central United States. Artificial inoculation of white pine gave negative results. The effects of the disease on hard pines are described.

MISCELLANEOUS TREE TROUBLES

There are tree diseases and health difficulties of eastern white pine about which there is very little accurate information. Some of these troubles are or may be associated with fungi or with viruses. Others may result from adverse environmental factors, a few of which are preliminary to infection by fungi. Most of them are of minor concern to the forester. However, those who are responsible for the care, culture, and management of white pine should be aware of the difficulties.

POOR PLANTING

The artificial establishment of seedling and transplant stock invariably causes root disturbances. Hurried and careless planting may cause severe entanglement of the roots. Such distorted roots are slow to extend themselves outward into the surrounding soil, thereby increasing the soil volume from which water can be secured. Many such transplants will die the season of planting and others the next season if adverse weather causes drought. The harmful effects of severe root distortion may persist in trees for 25 or more years and cause premature death. Death may be hastened by root rot fungi which characteristically attack only weakened and dying roots of non-vigorous trees. Progressive chlorosis, dwarfed needles, early loss of all but the current-season needles, and reduced terminal growth are evidences associated with poor root systems.

Improper choices of site and soil also are factors in the artificial establishment of white pine that affect growth and mortality adversely. Evidences of the effects of these unfavorable conditions are often similar to those associated with crippled roots.

269

Hepting, G. H. and A. A. Downs. 1944. Root and butt rot in planted white pine at Biltmore, North Carolina. Jour. Forestry 42 (3):119-123.

See Abstract No. 57. Reference is made to the probable relation of root rot and poor planting.

270

Hirt, Ray R. 1957. Canned trees. Arborist's News. 22 (6):41-43.

In the course of research on white pine blister rust, over 40,000 eastern white pines were grown briefly in containers. At planting time, to establish plantations, the roots were straightened and most of the plants grew well. When occasional trees failed to develop normally, the condition was usually associated with severe root entanglement.

271

Wahlenberg, W. G. 1955. Six thinnings in a 56-year-old pure white pine plantation at Biltmore. Jour. Forestry 53 (5):331-339.

See Abstract No. 63. (*Fomes annosus* infection vs poor planting.)

272

York, H. H. 1940. Relative susceptibility of young pine trees in artificial and natural stands to invastion by bacteria and fungi. Phytopath. 30 (1):28.

"Investigations over a period of 10 years in forest plantings of white, red, and Scotch pines indicate that there is a definite relation between the way in which trees are set in the ground and their susceptibility to infection in the root crown by fungi and bacteria". Natural seedlings are less susceptible to invasion by these organisms.

NUTRITIONAL DISTURBANCES

In reforestation projects young plantations are established all too frequently on "worn out" soils, with no provision being made to supply the deficient soil constituents essential to plant life. Within a few years evidences of starvation appear in the young trees, since they are unable to carry on photosynthesis at a level essential to good health. Such symptoms of poor health are similar to those resulting from root disturbances of several kinds. However, deficiency troubles probably result in a more uniform appearance of symptoms throughout a planting, except where there are pronounced differences in the soils of the planting area. Nutritional diseases in conifers are difficult to diagnose and to separate from difficulties caused by certain unfavorable environmental factors.

273

Heiberg, S. O. and D. P. White. 1951. Potassium deficiency of reforested pine and spruce stands in northern New York. Soil Sci. Soc. Amer. Proc. (1950) 15:369-376.

Pinus strobus was one of several species of conifers planted on old fields deficient in certain essential soil constituents. After 5 to 6 years evidences of poor health developed, such as: dwarfing of needles; few years of needle retention; decreased height and diameter growth; general chlorosis and needle necrosis; and finally death of individual trees. Short internodes gave the appearance of tufted foliage. Soil mulches of logging debris, forest humus, and commercial fertilizer produced strong growth response. Potash fertilization resulted in a pronounced response which continued for at least 6 years after the single application.

CHEMICAL INJURIES

Eastern white pines are occasionally subjected to toxic gases from commercial establishments and to excessive accumulation of chemicals in the soil. Toxic gases cause the needles to turn red-brown,

then brown as the needles die. The symptoms are difficult to distinguish from certain other causes of poor health. Roadside trees may be adversely affected and even killed by concentrations of calcium chloride and sodium chloride which drain from roads and accumulate in the soil occupied by the tree roots, where the chemicals have been used in large amounts to melt snow and ice or settle dust.

274

Brooks, A. B. 1911. Injuries due to smoke and gas. West Virginia Geological Survey 5:74.

White pine and hemlock in West Virginia are subject to lethal injury from the smoke and gas of coke ovens and paper pulp mills. (Of interest only because it is one of the early reports of fume injury to southern forests.)

275

Snell, W. H. and N. O. Howard. 1922. Notes on chemical injuries to eastern white pine (Pinus strobus L.) Phytopath. 12 (8):362-368; 12 (1):59.

Two kinds of injuries are reported as caused by: toxic fumes; and excessive concentrations of chemical salts in the soil. Symptoms of trouble were similar in both instances. The fumes were from the burning of coal, probably with a high sulphur content. The chemical salt was calcium chloride.

276

Quirke, D. A. and H. V. Hord. 1954. Condition of white pine in the Sudbury (Ontario) district. Canadian Dept. Agric. Ann. Report. Forest Insect and Disease Survey. P. 74.

A brief statement of the cumulative effects of sulphur fumes on needles of *Pinus strobus* is presented. Reference is made to statements in a previous Annual Report. Excessive mortality in sample plots adjacent to fume sources occurred in small trees as well as codominants and dominants.

SALT SPRAY INJURY

Under certain storm conditions ocean spray is carried inland in sufficient amount to affect the foliage of some tree species. White pine apparently is very subject to damage by the salts contained in the spray. Although this type of injury is relatively rare, it occurs sufficiently frequently that foresters should be aware of it.

277

Davidson, A. G. 1955. Salt spray. Canadian Dept. Agric. Ann. Dept. Forest Insect and Disease Survey. P. 25.

Along the south shore area of Nova Scotia and certain other coast areas of the Atlantic Provinces, browning of white pines was attributed to salt spray blown inland by a severe hurricane in September, 1954.

278

Moss, A. E. 1940. Effect on trees of wind-driven salt water. Jour. Forestry 38 (6):421-425.

The hurricane of September, 1938, carried ocean spray inland for as much as 45 miles. Many trees of various species were severely injured by the salts. White pine was the most sensitive to the ocean spray. Near the shore the

needle damage was most severe. Needle color was similar to fire-killed trees, but with a more orange cast. By November 1, clusters of needles with less than 20 per cent green tissue fell. Twigs devoid of live needles were shrunken and the buds dead. Some individual branches were killed. The damage became progressively less with increased distance from the shoreline.

279

Wallace, R. H. and A. E. Moss. 1939. Salt spray damage from recent New England hurricane. 15th Natl. Shade Tree Conf. Proc. Pp. 112-119.

Eastern white pine was the most susceptible to injury by ocean spray of all the coniferous species examined. If needles are killed for three-fourths of their length they will be shed, if less, they will be retained. Buds, small twigs, and large branches were also killed.

280

Wyman, D. 1939. Salt water injury of woody plants resulting from the hurricane of September 21, 1938. Arnold Arboretum Bull. of Popular Inform. Series 4, 7 (10):45-52.

Pinus strobus is listed among the plants killed or very seriously injured by salt spray, submergence in salt water, or both.

SUNSCALD

Young white pines of sapling age have relatively thin bark which, when subjected suddenly to afternoon summer sunshine, may be severely injured or killed. Such sudden exposure may result from severe pruning along the south or west edges of a plantation as well as from opening a north-south road or fire lane through a young stand. The writer has observed young ornamental pines that were removed from a partially closed plantation and set in the open along a drive. Every tree developed severe sunscald or heat canker on the southwest exposure of the trunk, followed soon afterward by severe decay. Sunscald can be recognized usually by continuous vertical narrow necrotic areas of bark or exposed sapwood, extending from near the root crown upward to the lowest whorl of live branches.

281

Huberman, M. A. 1943. Sunscald of eastern white pine, *Pinus strobus* L. Ecol. 24:456-471.

See Abstract No. 201. Also No. 287.

SNOW, FROST, AND FREEZING INJURIES

Heavy wet snow fall as well as severe drifting of snow over young pines may cause the leaders to be bent beyond the point of recovery, even though the terminals may remain alive. This results in sharply bent stems within a foot or two of the ground. In areas of drifting snow the writer has seen plantings of pine that were made worthless, except for ground cover, because of severely bent trunks. With age

and as a result of various stresses on the distorted areas of the trunk, cracks developed through the bark within which wood decay fungi became established. In a few instances the normally saprophytic fungus *Lenzites saepiaria* (Wulf.) Fr., caused decay in the ruptured crooks of the living trunks.

Late spring frosts as well as summer frosts may kill opening buds and immature tissues and distort young terminals. If repeated, dwarfing and abnormally developed stems will result. Extremely low temperatures may be the direct cause of death of needles and terminal buds during winter.

282

Curry, J. R. and T. W. Church. 1952. Observations on winter drying of conifers in the Adirondacks. Jour. Forestry 50 (2):114-116.

This is a report of winter drying during the winter of 1947-1948. By March 1948, needle browning was severe. It is suggested that long periods of bright sunshine and consequent rises in needle temperatures stimulated needle transpiration when frozen trunks prevented water renewal in the foliage. Death of an occasional white pine took place but most recovered. White pine is less subject to winter drying than red spruce and hemlock.

283

Davis, W. C., G. Y. Young and L. W. Orr. 1939. Needle droop of pine. Jour. Forestry 37 (11):884-887.

Needle droop is reported on current season growth of several pine species, including eastern white pine in the Lake States. It appears to result from unfavorable factors such as drought, heat, and frost. It is believed the trouble will be of little consequence.

284

Morey, H. F. 1935. The effect of abnormal weather conditions during 1934 on vegetation in the Northeast. Northeastern Forest Expt. Sta. Occasional Paper No. 4. P. 5.

Winter kill of eastern white pine due to low temperatures during February and March, 1934, occurred in areas of north-central Massachusetts, southern New York, and central Vermont. Needle necrosis and death of terminal buds were reported from north-central Maine and northwestern Massachusetts. White pine was the least affected of any species at Newcomb, New York.

285

Morse, W. J. 1910. Notes on plant diseases in 1908. 25th Ann. Report Maine Agric. Expt. Sta. for 1909, Bull. No. 164:1-28.

Winter injury of young eastern white pine, in Maine has been referred to generally as "pine blight." In early spring tufts of needles die and in severe cases small trees may be killed. Twigs on surviving trees may be killed back several inches. The trouble is attributed to excessive transpiration at times when the frozen soil does not permit replacement of water.

286

Pomerleau, René and R. G. Day. 1957. Occurrence and effects of summer frost in a conifer plantation. Canadian Dept. Northern Affairs and Nat'l. Resources. Forest Res. Div. Tech. Note No. 51.

This is primarily a report of the effects of summer frost on red pine, but eastern white pine is also referred to. A careful study of a pine plantation on the Valcartier Forest Experiment Station lands, revealed that the extensive killing of red pine, and to a lesser extent, eastern white pine, was due to summer frosts, particularly during July and August. Severe damage occurs only when low temperatures are present between bud opening and the "hardening" of shoots and needles.

287

Stoeckeler, J. H. and P. O. Rudolf. 1949. Winter injury and recovery of conifers in the upper Midwest. U.S. Dept. Agric. Forest Service, Lake States Forest Expt. Sta. Station Paper No. 18.

Winter injury to conifers in natural forest areas of the Lake States is somewhat infrequent, but does occur when unseasonably warm weather is followed by sudden drops in temperature, and when warm dry days occur while the soil is frozen. A combination of conditions during the winter of 1947-1948 produced injury in several midwest forest areas. Planted and natural eastern white pines showed extensive needle browning, but recovery was good. Sunscald occurred on the southwest side of the trunks in some stands. It is suggested that by proper selection of species and seed sources and use of certain cultural practices, future losses from severe winter conditions can be minimized.

288

Stone, E. L. 1952. An unusual type of frost injury in pine. Jour. Forestry 50 (7) :560.

Five species of pine including *Pinus strobus* showed a peculiar crook in the terminals produced in 1950 in certain areas of central New York. These were found to be the result of late frost injury. An excellent illustration accompanies the article.

FLOOD INJURY

Natural flooding of woodland areas happens occasionally. If the condition persists too long, the flooded trees will die. Although white pine is not the most tolerant tree species to flooding, young pines can withstand brief periods without disastrous results.

289

Ahlgren, C. E. and H. L. Hansen. 1957. Some effects of temporary flooding on coniferous trees. Jour. Forestry 55 (9):647-650.

The effects of natural flooding upon certain conifers for 10 to 123 days in northern Minnesota are reported. Eastern white pine was less tolerant of flooding for periods up to 48 days than balsam fir, black and white spruce. Flood periods of greater duration killed white pine. In the white pines that survived flood periods, terminal growth rate was reduced; the original foliage was killed, and the per cent of recovery dropped with increased periods of submergence.

FORKING DISEASES

Recently this disease of eastern white pine has caused some concern. A similar disease of red pine has been studied, and the suggestion made that it might be caused on red pine by the action of a phytohormone, produced by a fungus frequently isolated from the diseased pines. Fungi have not been reported as the cause of forking in *Pinus strobus.*

290

Honey, E. E. 1944. Tree diseases observed in Wisconsin. Forking. Plt. Dis. Rept. 28 (6):174:176.

The causes of forking in *Pinus strobus* are not completely understood, but are of considerable concern. Forking occurs in planted pine and natural reproduction. It seems to be asssociated with deer browse, precocious bud development, and debudding by animal life, as well as other factors.

DROPSY

Occasional young trees of eastern white pine develop an unusual amount of phloem tissue and a relatively small proportion of xylem within successive internodes. Thus the stem appears swollen and is unduly pliable. Various field workers have observed and reported such diseased young trees but apparently no detailed study has been made to determine the cause. The writer has never seen such diseased trees over 5 to 6 years old. It is not known whether they recover from the trouble or die at an early age. The name of the disease is misleading since the trouble is probably not associated with excess water. The writer has found affected trees growing on relatively dry sandy soils.

The disease is referred to in Forest Pathology, Second Edition by J. S. Boyce, page 49.

BROOMING AND DWARFING

Brooming of eastern white pine, although uncommon, is of two kinds. One type is the so-called witches broom that involves a distinctly localized proliferation of twigs on branches in the crown of a tree. Another type of broom involves the whole tree, starting when the tree is young, and causing excessive dwarfing. In the latter type of broom no single terminal is produced, but apical growth of each branch involves three to five dwarfed terminals. This results in a natural round, compact slow-growing globe of green foliage that should be useful in arboriculture as an evergreen shrub for foundation plantings.

The writer has such a tree of considerable age, and over several years has made grafts on seedling stock of white pine. The brooming character is continued in the scions without change, and has given no evidence of affecting the growth of the stock upon which the scions became established. This indicates that a virus probably is not involved.

The cause of brooming in white pine is unknown.

291

Chisman, H. H. and N. Lylo. 1958. A dwarf form of eastern white pine (*Pinus strobus* L.). Jour. Forestry 56 (2):110-112.

Forty-seven dwarf eastern white pines were found on farm woodlands of the Pennsylvania State University. A study of the distribution of the dwarf trees located the probable parent of the dwarfs. The dwarf pines are probably not a new variety but can be identified as *P. strobus* var. *nana* Hort. A detailed description of the dwarfs is given.

292

Honey, E. E. 1944. Tree diseases observed in Wisconsin. Witches-broom. Plt. Dis. Rept. 28 (6):176.

"Individual white pines from 20 to 40 feet in height with large witches brooms at or near the top of the trees have been recorded in Langlade and Portage counties". The cause is not known.

MISTLETOE

The eastern dwarf mistletoe, *Arceuthobium pusillum* Peck has been reported only once on eastern white pine, and therefore is of no concern on that host at present. Reference to this is made in Forest Pathology, 2nd Edition, J. S. Boyce, page 311.

293

House, H. D. 1935. Dwarf mistletoe on white pine. Rhodora 37 (439):268.

Arceuthobium pusillum Peck was present on white pine in Clinton County, New York. The specimen collection came from an area of infected white spruce, a common host of the dwarf mistletoe.

NEEDLE BLIGHT AND CHLOROTIC DWARF

These diseases have been discussed under the section "Plantation and Forest Trees — Foliage Diseases," and are noted here only because the actual cause or causes of these apparently related troubles have not been determined with complete assurance as yet.

SMOTHERING

A smothering disease of seedlings results from partial or complete enfolding of seedlings by the fruiting structures of the fungi involved. The seedlings may or may not be killed, but if they die, it seems to be the result of shading and perhaps interference with respiration and transpiration, rather than actual invasion of the seedling tissues. The trouble seems to be of little consequence in the reproduction of eastern white pine.

Insufficient oxygen due to excessive soil moisture has been reported as a possible cause of abnormal enlargement of root lenticels in certain conifers, including eastern white pine. Smothered seedlings due to heavy snow cover are sometimes overgrown by saprohytic fungi.

294

Hahn, G. G., C. Hartley and A. S. Rhoads. 1920. Hypertrophied lenticels on the roots of conifers and their relation to moisture and aeration. Jour. Agric. Res. 20 (4):253-266.

On certain conifers including eastern white pine, an overabundance of hypertrophied lenticels were present on the roots. The hypertrophies have the structure of lenticels. They occur on both weak and vigorous plants, in various soils with excessive moisture, and may be associated with insufficient oxygen.

295

Hedgcock, G. G. 1932. Notes on the distribution of some fungi associated with diseases of conifers. Plant Disease Reporter 16 (4):28-42.

Neopeckia coulteri (Peck.) Sacc. was found on dead and dying needles and twigs of eastern white pine in Montana. The fungus is considered to be saprophytic, becoming established on needles and twigs killed by lack of air under hard-packed snow cover. The fungus is designated as a "black snow-smother fungus".

296

Weir, J. R. 1921. *Thelephora terrestris, T. fimbriata,* and *T. caryophyllea* on forest tree seedlings. Phytopath. 11 (3):141-144.

The several fungi are discussed in respect to their effects on tree seedlings. The accompanying photograph of the fungus and enclosed seedlings is excellent. Eastern white pine seedlings are not mentioned. (This reference is included since the present writer has found *T. terrestris* very frequently enveloping seedlings of *Pinus strobus* growing as natural reproduction on sand flats of the Pack Demonstration Forest, Warrensburg, New York.)

SOOTY MOLD

Sooty mold of eastern white pine and other conifers results from a species of *Dimerosporium* growing upon the secretions of aphids which, in turn, feed upon succulent stem tissues of the conifer hosts.

When severe, the joint effects of insect feeding and shading by the fungus may cause temporary chlorosis of the affected needles and some degree of needle dwarfing. The trouble is usually temporary, localized on individual trees, and of no concern to the forester. It is associated with young trees.

BLUE STAIN

Blue stain fungi become established in living trees, so far as known, only as they are associated with infestations of bark beetles. The fungi appear to be a factor in hindering recovery or hastening the death of infected trees.

297

Rumbold, C. T. 1931. Two blue-staining fungi associated with bark-beetle infestation of pines. Jour. Agric. Res. 43 (10):847-873.

In 1931, near Petersham, Massachusetts, *Ceratostomella ips* was isolated from *Pinus strobus* infected with *Ips pini*. The paper is not concerned primarily with infection of eastern white pine by the blue stain fungus. Emphasis is placed on infection of southern hard pines. The two fungi *C. pini* Munch. and *C. ips* n.sp. are described and related to their bark beetle associates and pine hosts.

SEPTOBASIDIUM PINICOLA

This fungus might be mistaken in the field as a pathogen. However, it is only an epiphyte on eastern white pine. It is frequently located on the under side of a branch at a crotch. Whereas it is of interest to the mycologist, it has no adverse effect in pine.

298

Bray, D. F. 1958. Scale insect notes from New England. Matsucoccus. Scientific Tree Topics 2 (5):19.

The fungus Septobasidium covers and is associated with the scale insect Matsucoccus. This insect has never been identified for species. The fungus and insect occur on white pine but no damage has been associated with either organism.

299

Overholts, L. O. 1924. *Septobasidium pinicola,* Snell. Mycologia 16 (5):233.

This records the presence of the fungus on white pine in Pennsylvania. It is typically on young thrifty trees 10 to 30 years old in quite dense association.

300

Snell, W. H. 1922. A new *Septobasidium* on *Pinus strobus*. Mycologia 14 (2): 55-60.

See Abstract No. 98.

STAIN AND DECAY OF WHITE PINE WOOD

Wood in storage and in service, when exposed to conditions favoring the growth of fungi, frequently develops objectional stain and decay. Wood stain fungi rarely affect the strength of wood to a measurable degree, however, they cause serious degrade because of undesirable discoloration. Incipient decay may cause objectionable color in wood, and even in its earliest stages can cause serious loss of strength.

Decay and discoloration of white pine caused by fungi can be controlled if proper precautions are observed. Control, however, is not a simple procedure. Fundamentally it is accomplished by: 1, quickly reducing and then retaining the moisture content of wood considerably below fiber saturation point; and, 2, by applying a fungicide (wood preservative). The preservative may be applied to the surface or throughout the wood by pressure. Future use to which the wood is to be put should determine the more desirable method of preservative application.

Wood-staining fungi quickly become established in moist wood, consequently fresh-cut lumber to be air dried during summer periods is frequently dipped in a water-soluable fungicide solution immediately after sawing and prior to piling. Kiln drying is another standard method of producing lumber free of discoloration.

Pressure treatment is the best method of applying wood preservatives to prevent decay of wood that is in contact with soil or other moist substrata. The application of preservatives by brush, spray, or dip gives excellent protection where wood is only briefly or occasionally moist, and subject primarily to contamination by fungus spores.

The following selected abstracts refer to discolorations and decays of eastern white pine wood and their control.

301

Atwell, E. A. 1931. Occurrence of *Cladophora fastigiata* in Canada. Phytopath. 21 (7):761.

This fungus was isolated from stained sapwood of several species of conifers grown in Canada. Cultured on sapwood blocks of white pine under controlled conditions, *C. fastigiata* produced an intense gray-green stain. It is probable that the fungus causes considerable stain of Canadian softwood lumber.

302

Baker, G. 1954. The durability of Maine woods for fence posts. Univ. of Maine. Forestry Dept. Tech. Note No. 33.

Eleven species of trees were used in these tests. White pine posts were cut from slim, heavily suppressed trees with relatively slow growth and a small amount of sapwood. The outer radial inch had a ring count of 30 to 40 rings, and the sapwood averaged less than one-half inch in thickness. After 8 years of service only red oak and northern white cedar had a better service record than eastern white pine. Of 10 white pine posts under test, only 2 were sufficiently decayed so as to fail when a 50-pound pull was applied 3.5 feet above the ground.

303

Brown, F. L. 1953. Mercury tolerant Penicillia causing discoloration in northern white pine lumber. Jour. Forest Products Res. Soc. 3 (4) :67-69; State Univ. College of Forestry at Syracuse Univ., 1951. Unpubl. Thesis.

Stain of eastern white pine wood by the mercury tolerant fungi *Penicillium cyclopium* West. and *P. crustosum* Thom, penetrates deeply and results from an abundance of blue-green conidia produced in the tracheids. The fungi pass through cell walls by way of the pits. No reduction in toughness was found in heavily stained eastern white pine wood. In culture, *P. crustosum* grew well in media containing 15.62 ppm. of a proprietary compound of ethyl mercury phosphate. The same fungus was inhibited by a concentration between 2.48 and 4.70 ppm. of pure ethyl mercury phosphate, indicating the desirability of using pure chemicals.

304

Crossley, R. D. 1956. The effects of five sapstain fungi on the toughness of eastern white pine. State Univ. Coll. Forestry at Syracuse Univ. Unpublished thesis.

Stain fungi vary in their effects on toughness of sapwood of eastern white pine. Loss in toughness is not always correlated with intensity of discoloration when different fungi are involved. *Alternaria tenuis* causes a uniform gray stain and reduces toughness by approximately 40 per cent. *Ophiostoma piliferum* and *O. ips* cause a blue-gray stain and reduce toughness about 30 per cent and 10 per cent respectively. *Cytospora pini* and *Leptographium lundbergii* cause blue-gray stain but do not affect toughness significantly.

305

Davidson, R. W. and F. Lombard. 1954. Brick red stain of sitka spruce and other wood substrata. Phytopath. 44 (10) :606-607.

The fungus, *Ascocybe grovesii* Wells was isolated from surface stained white pine lumber in 1950. The lumber came from The Braeside, Ontario, Canada. A brick red stain is associated with the fungus. On white pine the discoloration appears to be superficial.

306

Fritz, C. W. 1929. Blue stain: a cause of serious loss to manufacturers of white pine lumber. The Forestry Chronicle 5 (3) :19-27.

This paper briefly discusses blue stain of eastern white pine lumber, its cause, and the conditions in the mill yard which favor blue stain development. Proper piling of lumber to provide a maximum of air circulation and heat of the sun will retard discoloration. No surface treatment with chemical is available that will control staining under favorable conditions for the causal agent. Kiln drying will prevent blue stain.

307

Fritz, C. W. 1929. Stain and decay in lumber-seasoning yards with special reference to methods of prevention. Canadian Dept. Interior, Forest Service Circ. No. 27.

In 1928 in eastern Canada, losses due to blue stain of eastern white pine lumber were estimated to be $1,000,000. This paper briefly discusses the nature of the causal agents of stain and decay, spread of the fungi through lumber, conditions that inhibit their spread and which should be considered in mill-yard lay-out and lumber piling.

308

Fritz, C. W. 1931. Prevention of sapwood stain in white pine in the seasoning yard. Canadian Forest Service, Dept. Int., Forest Products Lab. Mimeo.

Laboratory and mill-yard tests were run using white pine lumber to test the effectiveness of certain chemicals in the control of fungi that discolor pine wood. Three Lignasan compounds gave the most promising results and trials on a commercial scale are suggested.

309

Fritz, C. W. 1952. Brown stain in pine sapwood caused by Cytospora sp. Canadian Jour. Botany 30 (4):349-359.

A fungus isolated from naturally brown-stained red pine sapwood was found to produce characteristic chocolate brown stain in sterilized red pine sapwood in culture. The causal agent was identified as a species of Cytospora. The effect of the fungus on bending strength and toughness was negligible. Occasionally the typical brown stain is found in wood of eastern white pine.

310

Hirt, Ray R. 1946. Control of wood decay by certain brushed-on preservatives. N. Y. State Coll. Forestry Circular. Revised 1950.

Careful research has proven that the brush treatment of wood with proper wood preservatives lengthens the service life of wood, including eastern white pine, very appreciably. The treatment by brush is most effective when the timbers are not in contact with soil and moist surfaces, but dependent upon contamination by fungus spores.

311

Wells, D. E. 1954. Ascocybe, a new genus of lower ascomycetes. Mycologia 46 (1):37-51.

A fungus, *Ascocybe grovesii* sp. nov., is described in detail. It is common in white pine storage yards throughout Ottawa valley, where it has been associated with "brown surface stain". It spreads rapidly in damp weather and is not restricted to sapwood. It causes a superficial stain readily removed by planing. It was not controlled by standard treatment with Permatox.

312

Zabel, R. A. 1953. Lumber stains and their control in northern white pine. Jour. Forest Products Res. Soc. Reprint.

The common stains of white pine lumber are discussed. Many of these are caused by fungi such as mold fungi, blue stain fungi, and those associated with decay. Preventative practices such as winter cutting, kiln drying, air seasoning with special piling and use of preventative chemicals are briefly covered.

Zabel, R. A. and C. H. Foster. 1949. Effectiveness of stain control compounds on white pine seasoned in New York. N. Y. State Coll. Forestry Tech. Publ. No. 71.

The results of experiments comparing the relative effectiveness of many sap-stain-preventative compounds applied to white pine wood for preventing stain are reported. The most effective was a mixture of ethyl mercury phosphate and sodium pentachlorophenate. Recommended concentrations of the effective compounds should be used to insure complete stain control. The preventative compounds are effective only when applied before the fungi become established beneath the wood surface. Fungi that caused a blue stain were species of Ophiostoma, the most common being *O. coeruleum* (Munch) Syd. Those commonly associated with gray and black discolorations belonged to the genera Alternaria and Leptographium.

SUPPLEMENTAL ABSTRACTS

While the manuscript was in the process of being printed and edited during 1958 and the spring of 1959, the following articles appeared in the literature.

DISEASES OF PLANTATION AND FOREST TREES

Current Surveys

314

Waters, W. E. and P. V. Mook. 1958. Forest insect and disease conditions in the Northeast. 1957. U. S. Dept. Agric. Forest Service. Northeastern Forest Expt. Sta. Paper No. 107.

Insect and fungus pests and their associated effects on forest trees during 1957 are listed. Diseases of white pine include: blister rust, root rot, needle blight, resinosis, general deterioration and winter drying.

315

Zabel, R. A., S. B. Silverborg and M. E. Fowler. 1958. A survey of forest tree diseases in the Northeast. 1957. U. S. Dept. Agric. Forest Service. Northeastern Forest Expt. Sta. Paper No. 110.

In the summer of 1957 an extensive tree-disease survey was conducted in the Northeast United States preliminary to an anticipated subsequent intensive survey, in order to formulate sound management policies and to establish major research needs and priorities. The results of the preliminary survey are reported. The major and minor diseases of eastern white pine are listed.

Stem Cankers

316

Boyce, J. S., Jr. 1958. Twig blight of eastern white pine caused by *Monochaetia pinicola*. Phytopath. 48 (9):516-517.

In 1957, *M. pinicola* was found associated with bark constrictions on twigs of seedlings and saplings of eastern white pine in Avery County, North Carolina. Inoculations with cultured mycelia produced typical constrictions on white pine twigs. The disease seems to be economically unimportant. An excellent photograph of cankered twigs is presented.

Blister Rust

317

Cafley, J. D. 1958. On white pine blister rust in plantations in Ontario. Forestry Chronicle 34 (1):57-61.

"White pine blister rust is a severe threat to young and middle-aged plantations only when these are located close to natural hardwood stands where ribes are present. The young and middle-aged plantation is self-protecting against white pine blister rust because of natural ribes eradication. White pine blister rust may be expected to be a threat to older plantations which, under certain management practices, may lack a closed crown cover for an extended period."

318

King, D. B. 1958. Incidence of white pine blister rust infection in the Lake States. U. S. Dept. Agric. Lake States Forest Expt. Sta. Forest Service. Sta. Paper No. 64.

Survey results indicate that rust hazard in the Lake States is greatest in the North and diminishes southward. The percentage of fatally infected white pines varied among hazard zones and among States in each hazard zone. In the low-hazard zone, an average 5-year loss of 0.6 per cent of the pines causes relatively little pine volume loss for the region as a whole. In the high-hazard zone, rust losses for 5 years averaged 6.3 per cent or 1.26 per cent of the remaining healthy pines each year. At this rate throughout a 100 year rotation, only 29 per cent of the trees in the initial stand would escape fatal infection. A table shows the estimated proportion of present unprotected white pine stand that will survive rust infection during 100-year rotation, by present age and hazard zone.

319

Klaehn, F. U. 1958. Forest tree improvement and its expectations. *In* Silvicultural Aspects of Woodlands. State Univ. Coll. Forestry Bull. No. 42. Pp. 39-50.

This is a brief but worthy discussion of forest tree improvement practices with special reference to the start of such work at the State University College of Forestry at Syracuse University. Reference is made to the selection, propagation and testing of an apparently rust-resistant specimen of eastern white pine.

320

Bega, R. V. 1959. The capacity and period of maximum production of sporidia in *Cronartium ribicola.* Phytopath 49 (1) :54-57.

The infection potential of the blister rust fungus depends in part on how many sporidia are produced per telial column, and the duration of weather conditions optimum for maximum production and dissemination of sporidia. The present paper presents additional evidence that relatively few hours of saturated air with low temperatures bring about germination of teliospores and subsequent casting of sporidia. Sporidium-cast is not instantaneous from a single column, but rises to a maximum, levels off, and then gradually subsides

Wood Decay

321

Linzon, S. N. 1958. Water content variation in the heartwood of white pine and its relation to incipient decay. Forestry Chron. 34 (1) :48-49.

Localized wet areas were found in white pine heartwood. They adjoined knots and extended vertically for varying distances. It is possible that the wet areas favor the growth of wood decay fungi. Further studies are anticipated.

MISCELLANEOUS TREE TROUBLES

Foliage Distortion

322

Anonymous. 1958. Unusual condition in white pine. Northeastern Forest Pest Reporter, U. S. Dept. Agric. Forest Service. Northeastern Forest Expt. Sta. No. 2. P. 7.

Young white pine reproduction in a cutover pine area of several acres, produced current-season growth that was unusually lush and succulent. The new needles were stiff, erect, and intensely green. Frequently bundles of 5 needles, although not fused, appeared as one thick needle. Lateral buds near the apical bud produced lateral shoots. No fungi or insects appeared to be associated with the abnormal growth.

Chlorotic Dwarf

323

Anonymous. 1958. Chlorotic dwarf of eastern white pine. Annual Report, 1957, Central States Forest Expt. Sta. U. S. Dept. Agric. Forest Service. Pp. 55-57.

Chlorotic dwarf occurs in young plantations throughout eastern United States. Death follows pronounced characteristic symptoms. (A good photograph of an afflicted tree is included in the report.)

324

Reid, James. 1958. Chlorosis of white pine needles. Annual Report, Forest Insect and Disease Survey, Canadian Dept. Agric. Biol. Div. Sci. Service 1957. P. 51.

Chlorosis is distinct from white pine needle blight. The only organism found consistently with chlorotic needles still attached to the tree and with fallen needls was *Lophodermium pinastri* (Schrad. ex Fr.) Chev. Possibly this fungus contributes to chlorosis but at present proof is lacking.

325

Schmiege, D. C. and R. L. Anderson. 1958. A gradual deterioration and dying of white pine. The Forest Insect and Disease Situation, Lake States, 1957. Lake States Forest Expt. Sta., Forest Service, U. S. Dept. Agric. Sta. Paper No. 60. Pp. 17-18.

A condition with symptoms similar to chlorotic dwarf of white pine appeared to be more common in 1957 than previously. Damage occurs on larger pines than reported for chlorotic dwarf, and also in natural stands. Decline is progressive followed by death within a few years after the first symptoms appear. In Grand Rapids, Minnesota, a high percentage of the white pine developed typical symptoms and died during recent years.

Stem Forking

326

McCabe, R. A. and R. F. Labisky. 1959. Leader forking of red and white pines in plantations. Jour. Forestry 57 (2): 94-97.

One of the chief factors which operates against normal growth is loss of leader dominance that results in forked trunks. Three major plantations comprising about 100 acres were given over to mixed stands of red, white and jack pine. These were planted between 1936 and 1951 in the University of Wisconsin arboretum. Forking occurred soon after planting. No obvious causative agent was apparent. Five possible reasons for forking are discussed.

Chemical Injury

327

Linzon, S. N. 1958. The influence of smelter fumes on the growth of white pine in the Sudbury region. Forest Biol. Div. Sci. Service, Canadian Dept. Agric. Contrib. No. 439.

Approximately 7000 white pine trees in the vigorous age class of 50 to 90 years were examined annually between 1949 and 1954. At less than 25 miles northeast of Sudbury, white pine foliage showed more extensive injury than foliage on trees further removed from the smelters. Annual growth declined near the smelters whereas a constant growth pattern was maintained in areas farther from the smelter fumes. Beyond 25 to 0 miles northeast of Sudbury in the direction of the prevailing wind, concentration, frequency, and duration of atmospheric sulphur dioxide apparently declined to a threshold value for the inhibition of growth of eastern white pine.

Septobasidium Pinicola

328

Reid, James. 1958. *Septobasidium pinicola* Snell. Annual Report, Forest Insect and Disease Survey, Canadian Dept. Agric. Biol. Div. Sci. Service. 1957. P. 51.

The fungus was reported on white pine for the first time in 1957 from 4 townships in the Pembroke District of Ontario.

DETERIORATION OF WHITE PINE WOOD

Decay

329

Linzon, S. N. 1958. *Peniophora phlebioides* Jackson and Dearden, a sapwood deteriorating fungus on eastern white pine. Canadian Jour. Botany 36 (1) :207-208.

In conjunction with a study of the effects of smelter fumes on forest growth in Ontario, data were secured on the deterioration of standing and fallen white pines and the succession of fungi. Among the numerous fungi recorded was *Peniophora phlebiodes,* not previously recorded as a saprophyte on *Pinus strobus.*

GIBBERELLIN EFFECT

330

Westing, A. H. 1959. Effect of gibberellin on conifers: generally negative. Jour. Forestry 57 (2) :120-122.

Gibberellin is a metabolic product of the fungus *Gibberella fujikuroi* (Saw.) Wr. The effects of applying gibberellin to seedlings of several conifers including eastern white pine are discussed. Ninety days after treating white pine seedlings no effects were observed. Treating seeds of white pine prior to germination appeared to have a very slight depressing effect. The general conclusion is reached that gibberellin has a comparatively minor effect on conifers.

STATUS OF DISEASE RESEARCH ON EASTERN WHITE PINE IN NORTH AMERICA

The Secretary of the Interior recently stated that, "Mounting losses from insects and diseases in all forest areas point to the urgent need for review of the past research findings and control measures. The development through research of effective and economical control methods is the first basic requirement to cope with the present increasing pest problems."[1]

Pinus strobus and its related native 5-needle coniferous species, are the only species of major forest trees in America that have been seriously threatened by an introduced foreign fungous pathogen, in which research has saved them from possible extinction as forest trees, and given to the forester a practical means of control.

Many years of research, field observations, and experience in the forest have produced considerable information about the various fungous diseases of eastern white pine. This available information properly evaluated and applied, should enable foresters to grow naturally established forests of white pine with a minimum of loss due to fungus activity.

New problems in tree health arise as time goes on and new research is needed. For example, infestation of white pine stands by the white pine weevil seems to provide areas of entrance and establishment for the red rot fungus. This is a problem that should have thorough study in order to determine with certainty what the relationship, if any, may be.

There is some evidence that the healing of wounds may cause pockets of established decay to become inactive. This is deserving of careful research since it could have a direct relation to the handling of vigorously growing pines with small, localized pockets of decay. The speed at which the important heartrots develop in relation to tree age, tree vigor, and various forest environments is not accurately known. Such information would be helpful in establishing sound management plans.

More knowledge regarding the relation of fungus diseases to the artificial establishment of white pine plantations is requisite and of prime importance. Certain diseases appear in artificially established

[1] Seaton, F. A. American forestry's programs for pest control and wildlife. Nat'l. Agric. Chem. Assoc. News and Pesticide Rev. 16 (1):5,11. 1957.

stands of eastern white pine that rarely if ever are reported in natural reproduction. The relation of tree growth and health to root entanglement and distortion that occurs during planting needs more study.

The use of antibiotics in the control of diseases associated with white pine offers much opportunity for profitable research. The promising results from preliminary tests in the use of acti-dione as a practical control measure for blister rust under forest conditions, is simply a pioneer effort within the field of tree medication. Root and butt rots, perhaps, might be retarded by chemicals properly applied to individual trees of great aesthetic value.

Research on the mechanics of disease resistance in eastern white pine in North America is relatively recent. A few specimens of *Pinus strobus* have been discovered that give evidence of resistance to the blister rust fungus. These are being tested to determine their degree of resistance and their desirability for tree breeding purposes, as well as their suitability for establishing seed tree orchards. Similar studies have been initiated recently on pines that appear to resist certain wood decay fungi. Studies of the fungi associated with these diseases are essential in order to discover whether there are strains of these fungi in America that vary in virulence. If evidence is found that strains of the fungi more virulent than others exist, and if evidence is discovered that these pathogens are in a status of change, then the significance of the studies on tree selection for disease resistance should be reviewed carefully and re-evaluated.

Disease is a composite of effects. Therefore cooperative efforts in such fields as plant pathology, plant physiology, mycology, ecology, genetics, entomology, silviculture and management, are essential in order to accomplish the best control of forest and plantation diseases.

The United States Department of Agriculture through its Forest Service is attempting to detect potentially destructive fungus and insect pests in their early stages, in order that control measures can be instituted promptly. Within the Forest Service a Division of Forest Pest Control is responsible for curbing disease epidemics on federal, state, and private forest lands, in part through cooperative effort.[2] Successful control of tree diseases must depend upon a thorough knowledge of the pathogens and their hosts. Thus research by competent investigators will continue to be a vital part of good forestry practice.

[2] Beal, J. A. and J. R. Hansbrough. The U.S. Forest Service's role in forest insect and disease control. Nat'l. Agric. Chem. Assoc. News and Pesticide Rev. 16 (1) :8,11. 1957.

CULTURE PRACTICES TO REDUCE DISEASE OF EASTERN WHITE PINE

General control measures for forest tree diseases are useful and may have wide application. However, each forest stand is an individual community influenced strongly by a localized environment. Therefore general disease control recommendations should be modified to meet the unusual influences of a local environment.

The following suggestions are directed toward the production of eastern white pine with a minimum of disease and that will experience the least risk of serious loss through premature death, defect, and cull. The suggestions have been gleaned from the literature, from conversations with foresters, and in some measure from personal experience. Perhaps the basic studies for some of the suggestions were not as prolonged and as extensive as might be desired. Future investigations may modify or even change the recommendations. For the present the following thoughts on disease control in white pine seem warranted. The silviculturist and forest manager will have to decide whether they are feasible or practical for specific application.

PLANTATIONS

SEED. Certain eastern white pines with special desirable characteristics are known. Some have excellent form; some have escaped weeviling in plantings with heavy infestation; still others have remained free of blister rust infection when the surrounding trees have died of rust or are fatally diseased; and some trees of advanced age are free of heartrot in stands where rot is prevalent. Even though all of these trees have not been tested for freedom of or resistance to the specific maladies or defects, they are probably the safest source of seed for presently starting plantations within the local areas. If tests indicate the desirable traits to be heritable, the trees should be multiplied vegetatively, and young plantings started to serve as future seed orchards and experimental tree breeding plots.

SEED AND TRANSPLANT BEDS. Seedlings are subject to damping-off and root rot. Soils with high humus content in the process of rapid decay are rich in those fungi that can destroy seedlings and young transplants. Standard practices of soil sterilization should be employed in seed beds, followed by good nursery procedures of shading, watering, fertilizing, and weed control.

PLANTING. More care while lifting planting stock and greater attention to proper root arrangement when young trees are set in the transplant beds and plantation areas, should result in better resistance to root rot and to drought and thereby provide for greater survival immediately after planting. The more normal root arrangement will lessen the danger of root rot in the sapling stage and later. The adverse effects of severe root entanglement and root girdling are well known in shade and ornamental trees; they are no less harmful enmass in plantation trees.

SOIL. Shallow, relatively wet clay soils should be avoided for planting. Soils with a hydrogen ion concentration approximating a pH of seven or above, may induce a lethal resinosis in pine trunks approximately 25 years after planting, and also favor the development of root and butt rot. If non-fertile soils are planted to white pine, organic mulches and inorganic fertilizers should be added as soil supplements.

SITE. White pine is relatively tolerant of various sites within its natural range. However, certain sites have hazards that may cause excessive loss, such as: industrial areas where fumes are abundant and prolonged; nearness to salt water where, during storms, salt spray will be blown upon the foliage; low land that may be flooded and young reproduction covered with water for prolonged periods; and pockets where late frosts frequently occur.

Sites where ribes are unusually abundant and difficult to eradicate, where they have seeded for many years, should be avoided for reforesting with white pine because of the blister rust hazard.

THINNING. The root and butt rot fungus, *Fomes annosus,* apparently thrives on stumps and dead roots that contain a maximum of reserve plant food. From these stumps where vigorous mycelial growth is built up, the fungus spreads to roots of nearby apparently vigorous trees and causes infection. Roots crippled by poor planting procedures are especially susceptible. Therefore leaving a minimum of stump wood and conducting thinning operations at a time when the researve starch is almost depleted, should greatly reduce the hazard of root and butt rot by *Fomes annosus.* Under certain conditions, poisoning of the stumps with a cheap easily-applied chemical toxic to root rot fungi, might be practical.

Precautions against sunscald of the trunks should be taken during thinning in order to avoid subsequent trunk rot that could cause appreciable cull in butt logs in later years.

PRUNING. Rot by *Stereum sanguinolentum* may follow pruning. The danger is lessened by pruning when the branches are small in diameter and by making close smooth cuts. Branches two or more inches across, pruned while alive, frequently have the wounds naturally covered with resin, which hinders fungus establishment. Advantage of this natural wound protection can be had by late spring and summer pruning. It is possible that similar precautions will assist in reducing infection by the red rot fungus, *Fomes pini*. While pruning, it is desirable to remove the dead stubs of leaders previously killed by white pine weevil. Such dead leaders persist for many years and may possibly serve as entry ways for the red rot pathogen.

INJURIES. During all operations that call for mechanized equipment, care should be exercised to avoid unnecessary wounding. The older the trees become, the greater is the hazard from open wounds low on the trunks and upon the roots. Effective fire control will reduce the opportunity for low trunk rot fungi to become established.

WHITE PINE BLISTER RUST. Specific directions for control of this disease are readily available and should be followed.

NATURAL FOREST

The same precautions against the establishment of disease that apply to young plantations, also apply to the young natural stands. The older stands will be invaded by root, butt and trunk rot fungi in spite of the best forest management practices, but they should be less abundant. Each stand is a project in itself. The type and frequency of salvage, sanitation, and thinning operations will be determined, among other factors, by the abundance and kind of pathogens present. The length of pathological rotations, so far as decay is a determining factor, will depend for most effective results, upon the kind of wood decay fungi most prevalent in a stand. Since the speed of decay of the most important heartrot fungi, *Fomes annosus, F. pini, Polyporus schweinitzii,* and *Stereum sanguinolentum,* is not known in eastern white pine, no accurate pathological cutting cycle can be suggested. When the fruit bodies or conks of these fungi are present on visible parts of infected pines, an appreciable amount of decay will be present in roots, trunks, or both.

Pathological problems in the plantation and forest, make up only one of the many factors that influence the management of a stand. Consequently they may be of major or of minor importance, but they should always receive consideration.

SOME GENERAL REFERENCE SOURCES

Anderson, O. C. 1928. The pathology of white pine. Unpublished doctorate thesis. State Univ. Coll. Forestry. Syracuse, N. Y.

Baxter, D. V. Pathology in Forest Practice. Second Edition. John Wiley and Sons, Inc. New York. 1952.

Boyce, J. S. Forest Pathology. Second Edition. McGraw Hill Book Co., Inc. New York. 1948.

Bibliography of Forest Disease Research in the Department of Agriculture. Misc. Publ. No. 725. Agnes Ellis Moore. U. S. Dept. Agric. 1957.

Check List of Diseases of Economic Plants in the United States. U. S. Dept. Agric. Dept. Bull. No. 1366. 1926.

Common Diseases of Important Shade Trees. United States Department of Agriculture. Farmer's Bulletin No. 1987. 1948.

Index of Plant Diseases in the United States. Plant Disease Survey, Agricultural Research Administration, U. S. Department of Agriculture. Part 5. Pinaceae-Zygophyllaceae. 1953.

Plant Pest Handbook for Connecticut. II. Diseases and Injuries. Connecticut Agricultural Experiment Station. 1934.

Annual Proceedings. Northeastern Forest Tree Improvement Conference. Beginning 1953. E. J. Schreiner, Editor, Northeastern Forest Experiment Station, Upper Darby, Pa.

Annual Reports. Forest Insect and Disease Survey. Forest Biology Division Science Service. Department of Agriculture, Canada.

Annual Reports. Lake States Forest Experiment Station. U. S. Department of Agriculture Forest Service.

Annual Reports. Proceedings of the Annual Blister Rust Conference. U. S. Department of Agriculture.

Annual Reports. White Pine Blister Rust Control. U. S. Department of Agriculture, Agricultural Research Service, Bureau of Entomology and Plant Quarantine.

Annual Reports. White Pine Blister Rust Control. Regions 7 and 8. U. S. Department of Agriculture, Forest Service.

Annual Reports from State Departments concerned with forest problems in the several states where eastern white pine is native.

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